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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 38.

Cultivation Experiment With Wheat, and a Special Study of the Moisture and Temperature of the Soil Under the Campbell and Ordinary Treatments.

Any farmer in the state can have the bulletins of the Station mailed to his address, free of charge, upon application.

Fargo, North Dakota, U. S. A.
April, 1899.

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CULTIVATION EXPERIMENT WITH WHEAT.

In the autumn of 1896, this Station began a series of cultivation experiments with wheat which have now been carried through two seasons. The results of the first year's work were published in Bulletin No. 29 of this Station, which publication also contains a complete outline of the plan of the experiment.

The original plan includes fifty-two plots, each one-fourth acre in extent. One-half of these plots are fall plowed while the other half are plowed in the spring. Each lot of twenty-six plots is divided into thirteen sets of duplicates. In addition to the duplicate plots there are eight single ones, containing one-fifth of an acre each. Four of these single plots are plowed in the fall and four in the spring. Three other one-fourth acre plots were added to the experiment this season which makes a total of sixty-three plots in the series. These plots represent thirty-seven methods of cultivation. Thirty-four plots in this series constitute seventeen pairs of duplicates on fall and spring plowed land.

The plan of cultivation for each plot or set of duplicates is outlined in tables 1 and 2, sufficiently clear, that a special explanation here is not considered necessary.

Plots No's. 6 and 19, 7 and 29, 12 and 25, 13 and 26, and 25 are harrowed soon after plowing.

Plots No's. 3 and 16, 4 and 17, 6 and 19, 11 and 24, 13 and 26 are sown with the Campbell drill in rows eighteen inches apart and cultivated with the Campbell cultivator.

All other plots are sown by the ordinary method with the Dowagiac shoe chain drill, in drill rows six inches apart.

Of the new plots added, plot 31 is rolled after sowing, plot 32 is rolled after sowing and harrowed a few days later, while plot 33 is harrowed immediately after sowing and is harrowed again a few days later.

This series of experiments is designed to test the relative merits of deep and shallow plowing, of disk plowing, ordinary plowing, and the cultivation of wheat in rows eighteen inches apart. These trials include the complete Campbell system and compare it with the ordinary methods of culture.

The virtues of sub-soiling of sub-surface packing, of harrowing after plowing and of rolling and harrowing after sowing are also compared.

WEATHER CONDITIONS AND CROP GROWTH DURING THE TRIAL.

In 1897, heavy rains and floods seriously interfered with the trial.

The season of 1898 was favorable to plant growth and large yields have been recorded.

The fall of 1897 was too dry to do good plowing. The winter follow-

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ing was also dry and quite mild. The spring of 1898 opened with the soil dry and loose and very little rain fell until seeding was completed. Table 8, gives, in a condensed form, the weather record for the season of 1898 and the condition of the crop from time to time. During the entire spring and summer a tri-daily record was made of the temperature at different depths in the soil and at different heights above the surface of the ground in a wheat field. A record was also made of the amount and rate of evaporation in a free exposure over the field and of the rise and fall of the water table.

The tri-monthly averages of these several records are given in table VII.

PREPARATION OF THE SOIL.

The fall plowed plots were plowed from September 16th to 28th, inclusive, in 1897, in the order of their unmbers. The soil of all the plots was hard, dry and quite lumpy. The cultivated plots averaged harder and more lumpy than those treated in the ordinary way, due perhaps, to having been cultivated during the previous summer when the ground was too wet.

The plow was started on April 13th in 1898 which was as early as the frost was out of the ground to a sufficient depth to allow a plow to run. The plowing of the spring plowed plots was completed April 22nd. The soil was in excellent condition—mellow and loose—and contained just enough moisture to handle well. It was observed however that certain small places or spots in nearly all of the cultivated plots were more or less gummy and hard.

In addition to the special treatment of individual plots indicated upon another page of this bulletin they were all given the following treatment: On April 19th to 22nd, inclusive, all plots both fall and spring plowed were harrowed with a spring-tooth harrow from north to south parallel with the furrows, and on April 22nd to 25th, inclusive, all of the plots were harrowed from east to west with an ordinary peg-tooth smoothing harrow. This put the ground in excellent condition except that some stubble and litter lay upon the surface. The spring plowed plots were more lumpy than those which had been fall plowed but they had less litter over the surface.

The disk plowed plots showed more litter than those which had been plowed with an ordinary mouldboard plow.

TIME AND RATE OF SEEDING.

The entire series of plots were seeded during an interval of three days, from April 25th to 27th inclusive, and fortunately no rain fell during that time.

The rate of sowing by the Dowagiac drill used on the ordinary plots was one bushel and six quarts of dry wheat per acre. The rate of seeding by the Campbell drill on the cultivated plots, was nine quarts per acre. The depth of sowing was two and one half inches to three inches and was about the same for each drill. Both drills run a little deeper on the spring plowed plots. All alley-ways except those at the ends of the plots were sown to wheat at the same rate per acre as the adjoining plot.

The seed used on all plots was from Experiment Station 66, a strain of fife wheat developed by the Station. All of the seed wheat was treated for smut with a formalin solution about one week previous to the time of seeding.

GERMINATION.

The surface soil was too dry at the time of seeding for the grain to sprout quickly, but a rain which fell three days after the seeding was completed hastened the sprouting and subsequent growth of the plants. On May 10th, thirteen days after the seeding was completed, the grain was up on all of the plots and formed a good uniform stand. No marked difference between the different plots could be noticed upon that date.

RESULTS FROM DIFFERENT METHODS COMPARED.

In considering the results obtained in this trial the reader should bear in mind that it is for two years only, in most part, and while valuable can not be taken as absolute proof in favor or against the methods compared.

In fairness to the plan of cultivating small grain known in the western states generally as constituting the major part of the Campbell system of culture it should be stated that the two seasons herein reported upon have not been dry ones. The season of 1897 was what is commonly called by practical men in this vicinity a "wet" season and 1898 was what they know as a "good" season i. e., neither wet nor dry. The Campbell system was especially designed to combat drouth and to extend grain growing into dry districts. It will thus be seen that future yields may change the average of total results. The figures published give the facts thus far obtained.

A light growth of mustard and wild oats and some large rag weeds and lambs quarter were pulled by hand from all of the plots irrespective of the method of cultivation. It was noted that they did not occur any more abundantly upon any particular plots receiving special treatment, hence it was considered fair to all methods.

Spring plowed plots No's. 12 and 15 and fall plowed plots No's. 2, 5, 7 and 14 were thrown out on account of damage caused by water standing upon them.

The plots of wheat were cut as they ripened and were threshed from the shock as soon as they were in good condition for it. All of the wheat was bleached more or less by heavy rains during the latter part of August. Little loss was sustained by shelling and it is believed that no unfairness occurred by reason of it.

The yields given in the following comparisons are taken from tables I and II and are the weights of wheat as it came from the machine. The wheat from all plots was clean but on account of bleaching it graded lower than usual. It was all graded No. 2 northern by J. W. Carroll of the Fargo Roller mills who inspected samples from each method of culture. It showed a slight variation in the percentage of hard wheat in the samples from different plots, ranging from 75 to 95 per cent.

The weight per bushel varied from 58 to 60¾ pounds. The average weight was a little less than sixty pounds per bushel. The only difference chargeable to any particular method of treatment was against the wheat from cultivated plots. Grain from the cultivated plots weighed a little less per measured bushel than that from other plots.

FALL COMPARED WITH SPRING PLOWING.

In this trial the numerous methods, of seeding and cultivation, tested have been carried out on both fall and spring plowing. This plan has given much data upon the relative merits of the two practices.

In 1898 the highest yield from single plots, and in several cases the highest average yield for particular systems of cultivation have come from spring plowed land. On June 23d, the wheat on the fall plowed plots was 15 inches high while that on the spring plowed ones was 12 to 13 inches high. The ground at that time was too dry for good growth no rain having fallen for sixteen days. The difference in height noted indicates that fall plowed land withstands drouth in June better than that which has been spring plowed. The grain was heading on July 4th. That on the fall plowing was a little more advanced than the grain on the spring plowed plots. The grain on the fall plowed plots ripened one to two days earlier than that on the spring plowing.

At maturity, 103 days from the date of sowing. the grain on the fall plowed plots varied less in comparative height than that on spring plowing while the average height was practically the same.

In 1897 the difference in favor of fall plowing was very marked on the general average as will be seen by the following tabular statement:

FALL PLOWING VS. SPRING PLOWING.

	Crop of 1898		Crop of 1897		Average for two years	
	Yield per acre	Net value per acre	Yield per acre	Net value per acre	Yield per acre	Net value per acre
	bushels		bushels		bushels	
Fall plowed plots, average ..	25.80	$ 8.17	17.93	$10.20	21.86	$ 9.18
Spring plowed plots, average	25.74	8.16	12.94	6.66	19.34	7.41
Difference..........	.06	$ .01	4.99	$ 3.54	2.52	$ 1.77

The difference in favor of fall plowing in 1898 was very slight. In 1897 the difference was nearly five bushels per acre in favor of fall plowing. There was no practical difference in the yield of straw in 1898 as will be seen by the following tabular statement:

	pounds
Average yield of straw per acre on fall plowed plots	2,410
Average yield of straw per acre on spring plowed plots	2,445
Difference	35

Trials at this Station covering a period of five years prior to the commencement of this experiment viz. from 1892 to 1896 inclusive gave the following results:

	Bushels per acre.
Spring plowing average for five years	17.8
Fall plowed, last of Sept., average for five years	18.0
Fall plowed, very late in Sept., average for five years	18.4

These figures show the difference found as an average for five years to be a little less than one half bushel per acre in favor of fall plowing.

The average for all trials covering a period of seven years gives the following:

	Bushels per acre.
Fall plowed land average for 7 years	19.2
Spring plowed land average for 7 years	18.2
Difference	1.0

It will be seen that the average results for seven trials in as many years gives a difference of one bushel per acre in favor of fall plowing land for wheat. The major part of this difference comes from the yields obtained for the season of 1897. The season of 1897 was wet which prevented early plowing and hence caused a great delay in seeding the spring plowed plots.

In this trial the plan is to follow the practice which the season requires and note any difference which persons operating on a commercial scale might find from the ones prevailing where such small parcels of land are worked. In 1897 the spring plowed plots were seeded six days later than the fall plowed plots which gave them a strong handicap for the season. The spring plowing was done as early as the land was in fit condition and the fall plowed plots were seeded as early as they were in good condition just as all of our neighboring farmers did and will always do with the land which they seed. The soil turned up lumpy both in the spring and fall of 1897 while the ground spring plowed in 1898 was in excellent condition and could be plowed early enough to be seeded practically as early as the fall plowed land. If the work had been done on a commercial scale a difference of seven to ten days in the time of seeding would have been the rule rather than the exception as it has been in this case where only small plots are handled. The practical item of early and late seeding must be studied as a separate problem. Results obtained from trials at this Station of early and late seeding indicate that late seeding would cause a decided lessening in the yield of grain.

CULTIVATING WHEAT.

The cultivated plots in 1898 doubled, tripled and in some cases quadrupled their yields of 1897 but they are still far behind the plots given ordinary treatment.

The season of 1897 was called by practical men a "wet" season and that of 1898 a "good" season. It is well known that the plan of cultivating small grain has been instituted for combating drouth, hence "wet"seasons and "good" seasons will naturally be the ones which will show most to its disadvantage. The cultivated wheat looked well early in the season but failed to fill well.

Notes taken June 23d, upon the growth of the grain read: "The cultivated wheat is making a rank growth, is dark green in color and can be distinguished by the heavier color when a mile distant from the plots. The cultivated wheat has stooled or tillered well, is more rank in growth and is more spreading and leafy than the ordinary sown grain."

The wheat on the cultivated plots ripened from three to five days later than that which was sown in the ordinary way. It also reached a greater height than that sown in the ordinary way. The heads were about one half inch longer but were not so well filled at the upper end as the ordinary sown wheat. The weight per bushel of the wheat from the cultivated plots was less than that from the ordinary sown wheat. This wheat was cultivated five times during the season on the following dates: June 1st, June 8th, June 14th, June 25th and July 18th.

The following table gives the yield for 20 cultivated plots and for 20 similar plots seeded in the ordinary way:

CULTIVATED VS. ORDINARY PLOTS.

	Crop of 1898		Crop of 1897		Average for two years	
	Yield per acre	Net value per acre	Yield per acre	Net value per acre	Yield per acre	Net value per acre
	bushels		bushels		bushels	
Ordinary plowing, avg	28.58	$9 77	19.28	$11.82	23.93	$10.80
Cultivated, avg	21.11	6.11	6.72	1.74	13.91	4.01
Difference	7.47	3.66	12.56	10.08	10 02	6 79

From the above table it will be seen that for the two years the cultivated plots averaged 10.2 bu. (10bu. 12lbs.) per acre less wheat than those given ordinary treatment. It will also be noted that the difference in favor of the ordinary method was practically seven and a half bushels per acre in 1898 and twelve and a half bushels in 1897.

The net profit per acre at the prices given upon another page of this Bulletin averaged $6.79 greater by the ordinary method for the two years. The grain on all of the cultivated plots was attacked by rust and blight very badly during the season of 1898. The rust appeared most on the south and west sides of the plots and also on the south and west sides of the culms or straw.

SECRETARY DISK PLOWING.

The results of the trial with the Secretary disk gang plow for the season of 1898 are at variance with those for the season of 1897. In 1897 they gave the highest yield of any treatment while in 1898 only the cultivated plots ranked below them in yield. The fall disk plowed plots yielded much better than those which were disk plowed in the spring.

The average result for two years make a fair showing for the disk plowing in comparison with other methods of treatment but they do not equal the results obtained by the ordinary method of culture as will be seen by the following statement of results:

SECRETARY DISK PLOWING VS. ORDINARY PLOWING.

	Crop of 1898		Crop of 1897		Average for two years	
	Yield per acre	Net value per acre	Yield per acre	Net value per acre	Yield per acre	Net value per acre
	bushels		bushels		bushels	
Ordinary plowing, average...	28.58	$9.77	19.28	$11.82	23.93	$10.80
Disk plowing, average.........	25.73	8.54	20.48	12.70	23.09	10.63
Difference........................	2.85	$ 1.23	—1.20	—$ .88	.84	$ .17

In 1897 the yield was 2.85 bushels (2 bu. 51 lbs.) per acre greater than for the ordinary plots but in 1898 the yield was 1.25 bu. (1 bu. 15 lbs.) less per acre than for the ordinary methods of treatment.

The average yield from the disk plowed plots for two years was .84 bu. (50 lbs.) less per acre than the plots getting ordinary treatment. The net value or profit per acre was 17 cents less than from the ordinary method.

The following statement shows the amount of moisture in the two plots at the time of seeding and at time of harvest:

DISK PLOWING VS. ORDINARY PLOWING.

Average Moisture Percentage for 1898.

	Percentage of moisture at the time of sowing		At harvest time, average for three feet	Loss during growth, average for three feet
	First foot	Average for 3 feet		
	per cent	per cent	per cent	per cent
Disk plowing, average	38.32	35.90	26.31	9.59
Ordinary plowing, average	37.07	33.19	24.54	8.64
Difference	1.25	2.71	1.77	.95

It will be seen that the disk plowed plots contained more moisture than the ordinary plots and gave up somewhat more of moisture during the growth of the wheat crop.

SUB-SOILING—DEEP AND SHALLOW.

The yields upon land sub-soiled 8 inches deep have been heavier each season of the trial than has the yield upon land given ordinary plowing, the difference being but slight for the two years. The following summarized statement gives the results obtained:

ORDINARY PLOWING VS. SUB-SOILING 8 INCHES DEEP.

	Crop of 1898		Crop of 1897		Average for two years	
	Yield per acre	Net value per acre	Yield per acre	Net value per acre	Yield per acre	Net value per acre
	bushels		bushels		bushels	
Ordinary plowing, average	28.58	$9.77	19.28	$11.82	23.93	$10.80
Sub-soiling, 8 in. deep, av.	29.55	9.32	20.10	11.44	24.83	10.38
Difference	—.97	$ .45	—.82	$ .38	—.90	$ .42

The average increase in yield for the two years was .9 bu. (54 lbs.) per acre wrile the net value or profits on sub-soiled plots at the prices named is 42 cents less than on land not sub-soiled. The sub-soiling was done in the fall of 1896 and is to be repeated every third year. It will thus require one more crop to fully equalize or determine the item of cost with the sub-soiled plots.

Trial plots subsoiled 3 to 6 inches deep gave a more variable result and one differing materially from the plots sub-soiled 8 inches deep.

ORDINARY PLOWING VS. SHALLOW SUB-SOILING.

	Crop of 1898		Crop of 1897		Average for two years	
	Yield per acre	Net value per acre	Yield per acre	Net value per acre	Yield per acre	Net value per acre
	bushels		bushels		bushels	
Ordinary plowing, average..	28.58	$ 9.77	19.28	$11.82	23.93	$10.80
Shallow subsoiling, average..	28.75	9.01	18.09	10 04	23.42	9 52
Difference...............	—.17	$ .76	1.19	$ 1.78	.51	$ 1.28

The average yield for the shallow sub-soiled plots was .5 bu. (30 lbs.) less per acre than for the plots receiving ordinary plowing. This difference came chiefly from the yield for 1897, however, for in 1898 the yield for the sub-soiled plots was practically the same as that for the ordinary ones.

The following summarized statements give the effect of sub-soiling upon the moisture:

SUB-SOILING 8 INCHES DEEP VS ORDINARY PLOWING

Average Moisture Percentage for 1898.

	Percentage of moisture at time of sowing		At harvest time, Average for three feet	Loss during growth, average for three feet
	First foot	Average for three feet		
	per cent	per cent	per cent	per cent
Sub-soiling 8 inches, avg..........	38.25	33.70	23.94	9.75
Ordinary plowing, average.........	37.07	33 19	24 54	8.64
Difference..........................	1.18	.51	—.60	1.11

SUB-SOILED 4 to 6 INCHES VS. ORDINARY PLOWING.

Average Moisture Percentage for 1898.

	Percentage of moisture at time of sowing		At harvest time, average for three feet	Loss during growth, average for three feet
	First foot	Average for three feet		
	per cent	per cent	per cent	per cent
Sub-soiled 4-6 inches, avg............	38 43	33.93	23.34	10.60
Ordinary plowing, average..........	37 07	33.19	24.54	8.64
Difference..............................	1.36	.74	—1 20	1.96

The surface foot of the soil contained approximately one and a fourth per cent more moisture at the time of seeding while the surface three feet contained from one half to three fourths of a per cent more moisture. It is also interesting to note that the sub-soiled plots gave up about one and a half per cent more moisture during the season than did the plots plowed 7 inches deep.

HARROWING AFTER PLOWING.

The results from harrowing after plowing were more marked upon fall plowed land than with that plowed in the spring. The following table gives the results:

HARROWING AFTER PLOWING VS. ORDINARY PLOWING.

	Crop of 1898		Crop of 1897		Average for two years	
	Yield per acre	Net value per acre	Yield per acre	Net value per acre	Yield per acre	Net value per acre
	bushels		bushels		bushels	
Harrowing after plowing......	29.30	$10.00	19 83	$12.10	24.57	$11.05
Ordinary plowing, average...	28.58	9 77	19.28	11.82	23 93	10.80
Difference........	.72	$ .23	.55	$ .28	.64	$ .25

Here we find a uniform difference in yield as compared with plots given ordinary treatment the average increase being .64 bu. (39 lbs.) per acre in yield while the net profit was increased 25 cents per acre. The difference should perhaps be slightly greater as the harrowed plot No. 7 on the spring plowed land was injured a little by water standing upon it for a time. The injury was not in the judgement of the writers, great enough to justify throwing it out of the trial.

The difference in the moisture content in 1898 was also in favor of the harrowed plots with the greatest difference occurring early in the season and in the surface foot of the soil. The following table gives the summarized results:

HARROWING AFTER PLOWING VS. ORDINARY PLOWING.
Average Moisture Percentage for 1898.

	Percentage of moisture at time of sowing		At harvest time, average for three feet	Loss during growth, average for three feet
	First foot	Average for three feet		
	per cent	per cent	per cent	per cent
Ordinary plowing, average.........	37.07	33 19	24.54	8.64
Harrowing after plowing, avg.....	35 16	32.45	23 95	8 50
Difference.......	1.91	74	.59	.14

SUD-SURFACE PACKING.

The plots sub-surface packed in 1897 gave 2.6 bu. (2 bu. 36 lbs.) heavier yield than did the ordinary plowed plots, but in 1898 the yield was 2 pounds per acre less than that for the ordinary plowed land:

SUB-SURFACE PACKING VS. ORDINARY PLOWING.

	Crop of 1898		Crop of 1897		Average for two years	
	Yield per acre	Net value per acre	Yield per acre	Net value per acre	Yield per acre	Net value per acre
	bushels		bushels		bushels	
Sub-surface packing, avg.	28 20	$ 9.32	21.88	$13.49	25 04	$11.41
Ordinary plowing, avg.	28 58	9.77	19.28	11.82	23.93	10 80
Difference	—.38	—$ .45	2.60	$ 1.67	1.11	$ .61

The fall plowed plots for 1898 show a slight increase in yield resulting from the packing while the spring plowed ones show a decrease in yield as a result.

The average of the trials for both years on spring and fall plowed plots show 1.1 bushels (1 bu. 6 lbs.) more wheat per acre and 61 cents greater net profit from the crop on the packed land.

No marked difference in moisture content is shown in 1898 from sub-surface packing:

SUB-SURFACE PACKING VS. ORDINARY PLOWING.

Average Moisture Percentage for 1898.

	Percentage of moisture at time of sowing		At time of harvest, average for three feet	Loss during growth, average for three feet
	First foot	Average for three feet		
	per cent	per cent	per cent	per cent
Sub-surface packing, avg.	36.29	33.23	24.51	8.72
Ordinary plowing, avg.	37.07	33.19	24.54	8.64
Difference	—.78	.04	—.03	08

The theory in regard to sub-surface packing is that by firming the soil at the bottom of the furrow a better capillary connection is established which tends to draw the water up into the surface soil. Whether this action takes place or not our tests, as far as the go; show a less moisture percentage in the surface foot of the packed ground.

SHALLOW PLOWING.

Plots plowed 3 inches deep gave a very much poorer yield in 1898 than did land plowed 7 inches deep, while in 1897 the yields upon the shallow plowed plots averaged slightly higher than those from deep plowed ones:

ORDINAAY PLOWING VS. SHALLOW PLOWING

	Crop of 1898		Crop for 1897		Average for two years	
	Yield per acre	Net value per acre	Yield per acre	Net value per acre	Yield per acre	Net value per acre
	bushels		bushels		bushels	
Ordinary plowing, average...	28.58	$ 9.77	19.28	$11.82	23.93	$10.80
Shallow plowing, average.....	26.86	9.03	19.56	12.03	23.21	10.53
Difference....................	1.72	$ .74	—.28	—$ .21	.72	$ .37

The average for the two years shows .72 bu. (43 lbs.) per acre heavier yield upon the deep plowed land. The net profit per acre was 37 cents greater upon the 7 inch plowing. The difference in the moisture content of the surface three feet was very slight.

SHALLOW PLOWING VS. ORDINARY PLOWING.

Average moisture percentage for 1898.

	Percentage of moisture at time of sowing		At harvest time, average for three feet	Loss during growth, average for three feet
	First foot	Average for three feet		
	per cent	per cent	per cent	per cent
Shallow plowing, average...........	37.02	33.40	24.71	8.69
Ordinary plowing, average..	37.07	33.19	24.54	8.64
Difference..........	—.05	.21	.17	.05

ROLLING AND HARROWING.

A single plot was added to the series in 1898 to give this method a trial. The ground was rolled or firmed soon after sowing, and was afterwards loosened by the harrow to produce a mulch over the surface. It gave the highest yield recorded for the series of trials.

ROLLING AND HARROWING VS. ORDINARY PLOWING.

	Crop of 1898	
	Yield per acre	Net value per acre
	bushels	
Rolling and Harrowing	31.77	$11.02
Ordinary plowing, average	28.58	9.77
Difference	3 19	$ 1.25

The result shows an increase in yield of 3.19 bu. (3 bu. 11 lbs.) per acre over the plots given ordinary tillage. The difference in the net value of the crop was $1.25 per acre. It should be borne in mind that this yield is for a single plot and for one season only and hence cannot be taken as a safe indication of what may generally be expected.

HARROWING WHEAT.

A single plot of wheat was harrowed immediately after sowing and was harrowed again six days later, which was two or three days before the grain came up, to learn the effect on the yield:

HARROWING AFTER SOWING VS. ORDINARY PLOWING.

	Crop of 1898	
	Yield per acre	Net value per acre
	bushels	
Harrowing after sowing	30 60	$10.49
Ordinary plowing	28 58	9 77
Difference	2,02	$ .72

It will be seen that an increase of 2.02 bu. (2 bu. 1 lb.) per acre resulted and a gain in net value of 72 cents per acre as compared with plots not so treated.

RELATIVE VALUE OF CROPS.

To emphasize the importance attached to this work, we have indicated in tables I and II the total cost per acre to produce the crop, by each of the methods employed, and the net value per acre of the crop in each case. The value of the crop is estimated in each case on the basis of 53 cents per bushel, the price received at the time of threshing, for No. 1 Northern wheat hauled from the College Farm.

In estimating the total cost of production of the crop, most lines of work were made a little higher, probably, than they would be to the average farmer. The estimates are as follows:

	PER ACRE.
Plowing with walking plow	$1.00
Plowing with the Disc Gang plow	.75
Sub-soiling with ordinary sub-soiler (per year)	.84
(Sub-soiling is usually done once in three years).	
Sub-soiling with the Disc Gang	.20
Spring tooth harrowing	.13
Peg tooth harrowing	.09
Seeding	.19
Rolling	.09
Cultivating grain, per cultivation	.12½
Sub-surface packing	.27
Harvesting	.62
	PER BUSHEL.
Threshing	.08
Seed wheat	.90

MOISTURE DETERMINATIONS.

Three complete determinations of the moisture contents of each plot were made during the season. The first set of samples was taken May 3d to 12th, a short time after sowing, and before much of the grain was up. A second set of samples was taken July 5th to 9th, when the wheat was heading, and the third set was taken August 10th to 15th, just after harvest. Part of the first set of samples including all of the fall plowed plots except Nos. 28, 29 and 30 were taken with a soil tube made after the pattern of the tube used by Prof. F. H. King of the Wisconsin Experiment Station. The remaining samples of the first and second sets were taken with a common wood auger.

Samples were taken with the auger and with the tube from the same plot and the percentage of moisture was compared. The auger samples showed the higher percentage of moisture. The auger method of sampling is preferable with our soil when it is moist and stickey. The ground was quite dry when the last set of samples were taken and the tube was used again in preference to the auger.

Each sample taken is a triplicate or is a composite from three holes

A plot of wheat grown by the Campbell system. The thermometer shelter shows on the left of the picture.

made in the same plot. An inch and a quarter auger was used for the first foot and an inch auger for the second and third feet. The samples thus obtained were found to be more nearly equal in bulk and weight than when the larger auger was used for each foot.

Favorable weather prevailed during the taking of each set of samples. Check samples taken on the last day of sampling from the first plot sampled showed very little change in moisture content. The greatest change or loss occurred between July 5th and 9th the time the second set of samples was taken. This was at a time when the grain was using a large quantity of water and a check sample showed a decrease of moisture as follows during the four days interval:

First foot	1.31 per cent.
Second foot	1.81 per cent.
Third foot	No change.

The soil samples were dried in a large vertical oven over a free gasoline flame. The temperature was maintained at about 110 degrees centigrade. The drying was continued for from twenty to twenty-four hours, or until the weights were practically constant. It was found that after a sample was thoroughly dry, continued heating caused a gradual slight increase in weight. All percentages of moisture are calculated on the dry weights of the soil.

EXPLANATION OF THE TABLES.

In tables I and II an outline is given of the plan of cultivation, the yield of wheat, the cost per acre and the net value of the crop for each of the several methods of cultivation in the trial.

The average yield per acre and net value of the crops for 1897, and the general averages for the two seasons are also included in the tables.

The words "harrowed" and "packed" as they occur unqualified in the tables indicate that these plots are harrowed or packed immediately after plowing, the latter operation being performed with Campbell's sub-surface packer. The complete Campbell system requires both operations.

Tables III and IV show the relation of the moisture content of the soil and the loss of moisture during the season of growth to the yield of wheat. Where there are duplicate plots only the average percentages of moisture are given. It is only fair to say that duplicate plots sometimes varied as much in moisture content as do the averages given in the tables. The columns marked "loss of moisture during the growth period" represent the computed difference between the percentage of moisture contained in the soil May 3d to 10th and August 10th to 15th, as indicated by the samples taken on those dates.

The plots which have been similarly treated have been grouped together in the tables for convenience in summarizing and making comparisons.

In tables V and VI, the methods of cultivation are thrown into groups showing the average yield and profit per acre for the several general methods of cultivation. Some of the average moisture percentages and the average loss of moisture from the first three feet of the soil during the period of growth have also been included.

Table VII gives the tri-monthly record for the season of the temperatures at several heights above and at several depths below the surface of the ground in a wheat field, also the amount of evaporation in inches determined by the use of an evaporometer made after the Piche pattern.

The essential features of the instrument are a graduated glass tube which is filled with water and allowed to rest upon a base covered with filter paper into which the water feeds and from which the evaporation takes place. By a comparison of the results given by this evaporometer with those obtained from a freely exposed water surface it was found that the evaporation recorded by the evaporometer exceeded that from the free water surface in the ratio of 1.2:1.

That the *air* temperatures given in this table are somewhat higher than the true mean for twenty-four hours is indicated by comparing these averages with the average daily temperature recorded by Frazier's self-recording thermometer. That instrument was not at hand until near the close of the season. The daily records by each method from July 31st to August 5th inclusive are compared in the following table:

MEAN DAILY TEMPERATURE.

DATE	July 31—Degrees Fah.	August 1—Degrees Fah.	August 2—Degrees Fah.	August 3—Degrees Fah.	August 4—Degrees Fah.	August 5—Degrees Fah.	Average—Degrees Fah.
Average of three daily readings—height 6 feet........	62.58	62.96	65.21	68.54	72.59	74.57	67.74
Frazier's Thermograph..................	57.25	59.81	61.81	61.15	66.94	69.89	62.81
Difference	5.33	3.15	3.40	7.39	5.65	4.68	4.93

The slightly lower readings of the thermometer at the height of six feet may be due to its having been supported near the roof of the thermometer shelter. The thermometer shelter was built in the ordinary way. It was seven feet high while the base was in the form of a rectangle two by three feet. The wet bulb thermometer was stationary. The dew point and relative humidity were calculated from tables prepared and used by the United States Signal service.

In table VIII is given the general weather and crop records for the season.

A SPECIAL STUDY OF THE MOISTURE AND TEMPERATURE OF THE SOIL UNDER THE CAMPBELL AND ORDINARY TREATMENTS.

Prof. Milton Whitney, Chief of the Divison of Soils of the U. S. Department of Agriculture placed one of his electrical moisture and temperature instruments with us during the past season for the special purpose of studying the relation between the moisture contents of the soil in wheat land handled by the Campbell method of culture compared with that sown and handled in the ordinary way.

On May 6th, the instruments were placed in position in plots 2 and 3, both fall plowed. (See table 1.)

The first readings were taken May 6th, and on and after May 13th, daily readings of the electrical resistance of both moisture and temperature in each plot at the respective depths of 3-6 inches and 21-24 inches were made until the close of the growing season.

It will be noted that plot 2 is shallow plowed. The plots are so arranged that it was not convenient to place the instruments so as to compare ordinary deep plowing with the Campbell treatment.

The upper diagram in Plate I shows the daily moisture percentages in the two plots at the respective depths mentioned. The daily electrical moisture resistances taken by us were forwarded directly to Washington. The moisture calculations were made under the direction of Frank D. Gardner of the Division of Soils, assistant in charge of field experiments. The following is an extract from a letter received from him Dec. 8th, 1898. He says: "The calculations sent you were made according to the second formula in Bulletin No. 12 of this Division. * * * The percentages are calculated on water free soil and are therefore higher than if calculated on the fresh soil. While there are a few slight irregularities, the results as a whole are quite satisfactory."

"Of the thirty Stations we have had under observation during the summer none have maintained so high a percentage of moisture as Fargo. You will notice from the diagram that there is only one day when any of the depths have less than 20 per cent of moisture and that the mean percentage for the whole season is somewhat greater than 30. The results seem to be slightly in favor of the Campbell treatment. Under this treatment the 3-6 inch depth has maintained more water than the ordinary treatment through the whole season. The drought seems to have been about two weeks later in reducing the moisture at 21-24 inches under the Campbell treatment than under the ordinary."

The following table gives the average daily moisture percentage in each plot at the resprective depths for each month or part of a month, and also the mean percentage for the whole season:

AVERAGE MOISTURE PERCENTAGES.

1898 Month	Campbell Treatment		Ordinary Treatment		Total rain fall
	Depth taken 3-6 ins.	Depth taken 21-24 ins.	Depth Taken 3-6 ins	Depth Taken 21-24 ins.	inches
May	43.08	34.40	42.53	34 68	2.41
June	38.19	35.00	35.38	34.19	2.29
July	33.64	28.55	32.30	28.23	2 58
August	25.54	22 90	23.09	24 27	.56
Average	36.47	31 59	34.63	31.16	7 84

The average moisture content for the whole season shows a difference in favor of the Campbell treatment of 1.84 per cent in the first six inches and 0.43 per cent at the 21-24 inch depth.

The lower diagram in Plate I shows the daily temperature in each plot at the respective depths given. These temperatures were calculated from the daily electrical temperature resistances by the use of tables prepared by Thomas H. Means of the Division of Soils, U. S. Department of Agriculture, who set the instruments in place at this Station and at our request standardized the electrodes for taking temperature resistance. The temperature like the moisture was taken only once daily, at 8 p. m. The curves then do not represent the average daily temperature but simply the temperature each day at a particular time.

It will be noticed that the temperature at the 3-6 inch depth was highest through the whole season in the Campbell plot, the greatest difference, 13 degrees, occuring May 17th. The greatest and most rapid changes of temperature also occur in the Campbell ground.

At the 21-24 inch depth the curves often cross each other and the temperature of the two plots seldom varies more than two or three degrees but the general average for the whole season is in favor of the ordinary treatment. At this depth the soil given ordinary treatment shows greater and slightly more rapid changes of temperature than the Campbell ground. The loose earth of the cultivated plots is subject to great and rapid changes of temperature but it seems to act as a blanket to keep the heat more uniform in the firmer soil below.

The following table gives the mean of the daily temperatures in each plot at the respective depths for each month or part of a month, and also the mean of the daily temperature for the whole season:

MONTHLY MEAN OF DAILY TEMPERATURES TAKEN AT 8 P. M. DEGREES FAHRENHEIT.

1898. Month	Campbell Treatment		Ordinary Treatment	
	Depth taken 3-6 ins.	Depth taken 21-24 ins.	Depth taken 3-6 ins.	Depth taken 21-24 ins.
May	58.30	43.51	57.33	46.35
June	64.93	54.91	62.52	55.12
July	71.54	58.99	64.79	59.79
August	70.22	59.03	....	60.23
Average	67.39	53.77	59.55	55.30

The mean of the daily temperature for the whole season shows a difference of 7.84 degrees in favor of the Campbell ground at the 3-6 inch depth, while at the 21-24 inch depth the difference is 1.53 degrees in favor of the ordinary treatment.

It should be remembered that these temperatures were taken only once daily, at 8 p. m. A few trial readings made at 7 a. m., show the temperature higher at the 3-6 inch depth in the ground receiving ordinary treatment than it was in the Campbell ground.

The cultivated ground gets warmer near the surface during the day but cools off more rapidly during the night than does the ground receiving ordinary treatment, while the latter allows more heat to penetrate deep into the soil than the former does.

TABLE I SHOWING THE RESULTS ON FALL PLOWED PLOTS.

Plot No's		Depth of plowing	Depth of sub-soiling	After Treatment	Method of Culture	Yield per acre			Cost of crop per acre	Net value of crop per acre	Crop of 1897		Average for two years	
Original	Duplicate					Original	Duplicate	Average			Yield per acre	Net value of crop per acre	Yield per acre	Net value of crop per acre
		in.	in.			bu	bu.	bu.	$	$	bu.	$	bu.	$
3 and	16	7	......	packed and harrowed	*C	19.67	21 82	20.75	5 17	5.82	8 43	3.09	14.59	4.46
4 and	17	6	......	....	C	19 27	19 82	19 55	4.46	5.90	8 22	3.20	13.89	4 55
6 and	19	6		harrowed	C	21 43	21 85	21 64	4 72	6.74	9.41	3.90	15 53	5.32
11 and	24	6	8	....	C	21 57	23.08	22 33	5 53	6 30	9.10	3.01	15.72	4.66
13 and	26	6	8	harrowed	C	21 77	24.50	23 09	5.68	6.55	8.49	2.37	15.79	4.46
1 and	14	6	......	ordinary	†Ord	28 60	27.20	27.90	5.34	9.46	21.15	13.15	24 53	11.31
2 and	15**	3	......	....	Ord	27.00	25.87	27 00	5.25	9 06	21 54	13 45	24.08	11.26
5 and	18	6	......	packed	Ord	29 53	27 03	28.28	5 63	9.36	23.39	14.56	25.84	11.96
7 and	20	6	......	harrowed	Ord	28 02	29.93	28.98	5.50	9.86	22.47	13 96	25 73	11.91
8 and	21	6	4	....	Ord	27 73	27 70	27.72	6.15	8.51	20.78	12 04	24.25	10 29
9 and	22	6	6	....	Ord	28 17	27 27	27 72	6.15	8,54	21.25	12.39	24.49	10.47
10 and	23	6	8	....	Ord	28 97	28 90	28.94	6 25	9 09	23.42	14.02	26.18	11 56
12** and	25	6	8	harrowed	Ord	27 97	29.57	29.57	6.39	9.28	22.38	13.01	25.98	11.15
‡	27	6	5	....	Ord	26.02	....	26.02	5 13	8 66	21.66	13.59	23.84	11.13
‡	28	6	5	harrowed	Ord	27 92	....	27.92	5.37	9.43	26.53	17.05	27 23	13.24
‡	29	6	......	....	Ord	27 10	....	27.10	5 02	9 34	25 94	15.95	26.52	12 65
‡	30	6	......	packed	Ord	26.13	....	26.13	5 21	8 64	23.43	14 85	24.78	11.75

*Cultivated in rows.
†Ordinary sown.
‡Disk plowed.
**Not included in the average because crop was damaged by wet weather.

TABLE II SHOWING RESULTS ON SPRING PLOWED PLOTS.

Plot No's		Depth of plowing	Depth of sub-soiling	After Treatment	Meehod of Culture	Yield per acre			Cost of crop per acre	Net value of crop per acre	Crop of 1897		Average for two years	
Original	Duplicate					Original	Duplicate	Average			Yield per acre	Net value of crop per acre	Yield per acre	Net value of crop per acre
		in.	in.			bu.	bu.	bu.	$	$	bu.	$	bu.	$
3 and	16	7	....	Packed and harrowed	*C	21.23	22.28	21.76	5.25	6.28	5.39	1.06	13.58	3.67
4 and	17	6	......	....	C	19.20	20.28	19.74	4.48	5.98	4.30	0.52	12.02	3.25
6 and	19	6	......	harrowed	C	20.23	23.07	21.65	4.56	6.91	5.28	1.06	13.47	3.99
11 and	24	6	8	....	C	18.57	19.10	18.84	5.26	4.72	3.86	—.66	11.35	2.03
13 and	26	6	8	harrowed	C	21.60	21.95	21.78	5.58	5.96	4.73	—.09	13.26	2.99
1 and	14**	6	.....	ordinary	†Ord	29.27	28.23	29.27	5.45	10.08	17.42	10.49	23.34	10.28
2** and	15	3	....	....	Ord	25.93	26.73	26.73	5.25	9.00	17.59	10.61	22.16	9.80
5** and	18	6	......	packed	Ord	25.90	28.13	28.13	5.59	9.29	20.36	12.42	24.24	10.85
7** and	20	6	....	harrowed	Ord	26.72	29.63	29.63	5.56	10.15	17.20	10.23	23.41	10.19
8 and	21	6	4	....	Ord	28.60	30.80	29.70	6.31	9.43	14.46	7.32	22.08	8.38
9 and	22	6	6	....	Ord	29.87	29.87	29.87	6.32	9.51	15.88	8.39	22.68	8.95
10 and	23	6	8	....	Ord	30.18	30.17	30.18	6.35	9.65	17.14	8.34	23.66	9.45
12 and	25	6	8	harrowed	Ord	29.87	29.10	29.49	6.39	9.24	17.30	9.37	23.40	9.31
‡	27	6	5	....	Ord	25.08	....	25.08	5.05	8.24	13.81	7.83	19.45	8.04
‡	28	6	5	harrowed	Ord	24.73	....	24.73	5.11	8.00	16.54	9.79	20.64	8.90
‡	29	6	.....	....	Ord	23.69	....	23.69	4.75	7.80	16.83	10.30	20.26	9.05
‡	30	6	......	packed	Ord	25.23	....	25.23	5.14	8.23	19.10	11.72	22.17	9.98
	31	6	.....	roll'd aft'r sowing.	Ord	29.17	....	29.17	5.52	9.94	....	....	....	....
	32	6	......	rolled and harrowed	Ord	31.77	....	31.77	5.82	11.02	....	.....	....	....
	33	6	.....	harrowed after sow	Ord	30.60	....	30.60	5.73	10.49	....	....	....	....

**Not included in the average because crop was damaged by wet weather.
‡Disk plowed.
*Cultivated in rows.
†Ordinary sown.

TABLE III SHOWING THE RELATION OF THE MOISTURE CONTENT OF THE SOIL AND THE LOSS OF MOISTURE DURING THE GROWTH PERIOD TO THE YIELD OF WHEAT. FALL PLOWED PLOTS.

Plot No's	System of culture	Samples taken Nov. 18, 19, 1897			Samples taken May 3-6, 1898				Samples taken July 5-6, 1898			Samples taken August 10-12, 1898				Loss of moisture during growth period				Yield of wheat per acre
		First foot	Sec. foot	Third foot	First foot	Sec. foot	Third foot	Avg.	First foot	Sec. foot	Third foot	First foot	Sec. foot	Third foot	Avg.	First foot	Sec. foot	Third foot	Avg	
		per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	bu.
3 and 16	*C	28.24	31.48	29.87	39.51	32.64	32.70	34.95	35.18	27.74	29.83	23.40	23.24	23.13	23.26	16.11	9.40	9.57	11.69	20.75
4 and 17	C	27.17	30.66	20.25	37.95	32.35	30.76	33.69	35.53	29.65	31.34	23.24	23.52	24.80	23.66	14.71	8.83	5.96	9.83	19.55
6 and 19	C	31.01	32.67	31.27	36.95	34.08	32.48	34.50	36.34	27.62	29.79	21.90	22.70	23.92	22.84	15.05	11.38	8.56	11.66	21.64
11 and 24	C	22.80	32.87	28.50	36.47	32.35	30.58	33.13	38.78	30.84	30.26	23.21	22.89	23.63	23.24	13.26	9.46	6.95	9.89	22.33
13 and 26	C	27.71	29.81	31.61	34.60	33.72	30.47	32.93	34.52	29.55	32.00	21.49	22.12	25.61	23.07	13.11	11.60	4.86	9.86	23.14
1 and 14	†Ord	25.55	32.80	31.72	39.00	33.08	32.07	34.72	38.36	29.76	27.31	23.27	24.76	24.92	24.32	15.73	8.32	7.15	10.40	27.90
2 and 15	Ord	28.70	32.15	30.65	39.32	33.87	32.61	35.27	37.77	28.26	29.88	24.95	25.35	24.89	24.97	14.37	8.52	7.72	10.30	27.00
5 and 18	Ord	27.93	33.14	30.66	39.49	33.55	31.39	34.81	32.13	26.95	29.77	22.70	24.18	25.66	24.18	16.79	9.37	5.73	10.63	28.28
7 and 20	Ord	30.86	32.70	30.75	36.35	32.71	31.52	33.53	36.27	29.11	30.06	21.36	23.55	25.25	23.39	14.99	9.16	6.27	10.14	28.98
8 and 21	Ord	27.05	32.83	32.73	37.48	31.54	30.84	33.29	35.99	27.83	28.85	21.31	22.61	22.70	22.21	16.17	8.93	8.14	11.08	27.72
9 and 22	Ord	27.58	32.22	32.74	36.69	33.89	30.41	33.66	37.44	28.68	29.61	24.04	24.63	23.77	24.14	12.65	9.26	6.64	9.52	27.72
10 and 23	Ord	26.63	31.47	29.62	38.32	30.93	30.69	33.31	35.82	29.47	29.52	23.67	23.79	22.74	23.40	14.65	7.14	7.95	9.91	28.94
12 and 25	Ord	27.22	31.92	32.28	39.77	32.90	29.48	34.05	36.56	27.54	30.82	22.07	22.92	25.92	23.64	17.70	9.98	3.56	10.41	29.57
‡ 27	Ord	....	....	....	34.88	34.39	31.85	33.71	37.28	29.63	30.35	24.09	25.40	28.54	26.01	10.79	8.99	3.31	7.70	26.02
‡ 28	Ord	....	....	....	38.68	34.01	33.67	35.45	35.86	27.79	33.95	26.34	26.36	28.80	27.16	12.34	7.65	4.87	8.29	27.92
‡ 29	Ord	....	....	....	36.11	35.02	35.69	35.61	34.59	31.41	35.14	25.04	25.29	24.26	24.87	11.07	9.73	11.43	10.74	27.10
‡ 30	Ord	....	....	....	39.16	38.27	35.27	37.57	36.67	31.14	35.08	23.18	24.20	26.67	24.69	15.98	14.07	8.60	12.88	26.13

*Cultivated in rows. †Ordinaay sown. ‡Disk plowed.

TABLE IV SHOWING THE RELATION OF THE MOISTURE CONTENT OF SOIL AND THE LOS
MOISTURE DURING THE GROWTH PERIOD TO THE YIELD OF WHEAT.
SPRING PLOWED PLOTS, 1898.

Plot No's	System of Culture	Samples taken May 9-12				Samples taken July 7-9			Samples taken Aug. 12-15				Loss of moisture during growth period			
		First foot	Sec. foot	Third foot	Avg.	First foot	Sec. foot	Third foot	First foot	Sec. foot	Third foot	Avg.	First foot	Sec. foot	Third foot	Avg.
		per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	por ct	per ct
3 and 16	*C	33.71	31.40	29.88	31.66	33.91	28.04	27.85	25.12	23.93	26.67	25.24	8.59	7.47	3.21	6.4
4 and 17	C	35.73	30.81	29.36	31.97	39.19	30.25	31.70	22.09	22.96	24.37	23.14	13.64	7.85	4.99	8.83
6 and 19	C	36.99	29.90	29.31	32.07	35.70	31.20	30.13	23.05	24.44	24.69	24.06	13.94	5.46	4.62	8.01
11 and 24	C	34.94	31.28	29.93	32.05	35.69	29.12	29.91	22.90	22.40	25.99	23.76	12.04	8.88	3.94	8.2
13 and 26	C	34.11	31.69	29.20	31.67	28.70	28.26	28.78	23.62	23.29	29.48	24.50	10.49	8.40	2.62	7.17
1 and 14	Ord	35.14	30.78	29.07	31.66	35.07	31.14	27.47	25.11	22.71	26.50	24.77	10.03	8.07	2.57	6.89
2 and 15	Ord	34.73	30.45	29.44	31.54	31.70	29.66	27.99	24.49	24.34	24.54	24.46	10.24	6.11	4.90	7.08
5 and 18	Ord	33.09	32.21	29.63	31.65	33.64	28.38	32.81	24.54	24.45	25.52	24.84	8.55	7.76	4.11	6.81
7 and 20	Ord	33.97	31.09	29.07	31.38	38.30	28.65	29.77	22.79	24.34	26.42	24.52	11.18	6.75	2.65	6.86
8 and 21	Ord	40.06	31.62	30.94	34.21	37.18	29.49	30.54	22.13	23.01	26.77	23.97	17.93	8.61	4.17	10.24
9 and 22	Ord	39.50	32.95	31.28	34.57	32.70	27.12	30.25	21.30	22.66	25.11	23.02	18.20	10.29	6.17	11.55
10 and 23	Ord	35.62	31.98	29.88	32.49	35.13	27.18	28.48	23.36	23.35	26.13	24.28	12.26	8.63	3.75	8.21
12 and 25	Ord	39.29	34.01	31.54	34.94	36.21	29.30	28.97	22.74	23.27	27.35	24.45	16.55	10.74	4.19	10.49
‡ 27	Ord	38.16	34.34	32.19	34.90	36.91	30.85	31.20	23.78	28.99	29.48	27.42	14.38	5.35	2.71	7.48
‡ 28	Ord	36.93	36.09	33.36	35.46	33.01	33.16	31.95	21.56	25.57	31.66	26.26	15.37	10.52	1.70	9.20
‡ 29	Ord	40.63	34.82	36.62	37.36	31.66	34.88	32.81	26.69	25.26	30.12	27.36	13.94	9.56	6.50	10.00
‡ 30	Ord	42.05	36.45	32.93	37.14	32.16	31.63	30.38	24.34	27.36	28.44	26.71	17.71	9.09	4.49	10.43
31	Ord	38.44	32.36	30.17	33.66	35.37	26.85	29.64	24.61	22.56	22.33	23.17	13.83	9.80	7.84	10.49
32	Ord	39.15	30.94	35.86	35.32	35.52	26.48	27.37	20.76	21.65	21.97	21.46	18.39	9.29	13.89	13.86
33	Ord	33.14	31.25	29.31	31.24	35.82	25.64	26.70	23.00	23.07	21.81	22.63	10.14	8.18	7.50	8.61

*Cultivated in rows. †Ordinary sown. ‡Disk plowed.

TABLE V SHOWING THE SUMMARIZED RESULTS FOR DIFFERENT METHODS OF CULTURE UPON FALL PLOWED LAND.

General Method of Culture	Number of plots tested	Average Moisture 1898				Yields and Net Value Per Acre					
		At sowing time		At harvest time, average for 3 feet	Loss during growth period, average for 3 feet	Crop of 1898		Crop of 1897		Average for 2 years	
		First foot	Avg. for 3 feet			Yield per acre	Profit per acre	Yield per acre	Profit per acre	Yield per acre	Profit per acre
		per ct	per ct	per ct	per ct	bu.	$	bu.	$	bu.	$
Cultivated	10	37.10	33.84	23.25	10.59	21.47	6.26	8.73	3.11	15.10	4.69
Ordinary Plowing	2	39.00	34.72	24.32	10.40	27.90	9.46	21.15	13.15	24.53	11.31
Shallow plowing	2	39.32	35.27	24.97	10.30	27.00	9.05	21.54	13.45	24.08	11.26
Sub-surface packed	2	39.49	34.81	24.18	10.63	28.28	9.36	23.39	14.56	25.84	11.96
Harrowed after plowing	2	36.35	33.53	23.39	10.14	28.98	9.86	22.47	13.96	25.73	11.91
Sub-soiled 4 and 6 inches	4	37.09	33.48	23.18	10.30	27.72	8.54	21.02	12.22	24.37	10.38
Sub-soiled 8 in.	4	39.05	33.68	23.52	10.16	29.26	9.19	22.99	13.52	26.13	11.30
Disk plowed	4	37.21	35.58	25.68	9.90	26.79	9.02	24.39	15.49	25.59	12.26

TABLE VI SHOWING THE SUMMARIZED RESULTS FOR DIFFERENT METHODS OF CULTURE UPON SPRING PLOWED LAND

General Method of Culture	Number of Plots tested	Average Moisture 1898				Yields and Net Values Per Acre					
		At sowing time		At harvest time, avg. for 3 feet	Loss during growth period, avg. for 3 months	Crop of 1898		Crop of 1897		Average for 2 years	
		First foot	Avg. for 3 feet			Yield per acre	Profit per acre	Yield per acre	Profit per acre	Yield per acre	Profit per acre
		per ct	per ct	per ct	per ct	bu.	$	bu.	$	bu.	$
Cultivated	10	35.10	31.88	24.16	7.74	20.75	5.97	4.71	.38	12.73	3.33
Ordinary plowing	2	35.14	31.66	24.77	6.89	29.27	10.08	17.42	10.49	23.34	10.28
Shallow plowing	2	34.73	31.54	24.46	7.08	26.73	9.00	17.59	10.61	22.16	9.80
Sub.surface packed	2	33.09	31.65	24.84	6 81	28.13	9.29	20.26	12.42	24.24	10.85
Harrowed after plowing	2	33.97	31.38	24.52	6.86	29.63	10.15	17.20	10.23	23.41	10.19
Sub-soiled 4 and 6 inches	4	39.78	34.39	23.50	10.90	29.79	9.47	15.17	7.86	22.48	8.67
Sub-soiled 8 in.	4	37.46	33.72	24.37	9.35	29.84	9.45	17.22	9.36	23.53	9.41
Disk plowed	4	39.44	36 22	26.94	9.28	24.68	8.07	16.57	9.91	20.60	8.99
Rolled after sowing	1	38.24	33.66	23.17	10.49	29.17	9.94	....	....	....	....
Harrowed after sowing	1	33.14	31.24	22.63	8.61	30.60	10.49	....	....	....	....
Rolled and harrowed after sowing	1	39.15	35.32	21.46	13.86	31.77	11.02	....	....	....	....

TABLE VII: SHOWING TRI-MONTHLY AND MONTHLY AVERAGES OF AIR AND SOIL TEMPERATURES, ETC.

From May 20 to August 6, 1896. Observations taken in the wheat field.

DATES.	Average Soil Temperatures—Depth Below Surface.					Average Air Temperatures—Height Above Surface.					Mean Dew Point	Mean per cent. of Relative Humidity	Average Daily Evaporation	Total Evaporation
	1 inch	6 inches	1 foot	2 feet	8 feet	8 inches	2 feet	4 feet	6 feet	Wet Bulb 4 feet				
	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Inches	Inches
May 20-31	61 34	55.36	51.58	46.17	42.94	60.69	61.23	61.47	60.89	54.00	48 91	60.94	.1982	1.9823
June 1-10	64.42	59.36	56.35	51.03	47.26	61.75	62.46	62.74	62.24	57.96	54.32	75.58	.1286	1.2865
June 11-20	69.10	62.08	59.20	54.32	50.45	64.31	64.96	65.37	64.85	60.15	56.93	74.05	.1842	1.8427
June 21-30	67.14	63.34	60.64	56.12	52.93	65.71	66.51	67.19	66.85	62.19	59.20	76.02	.1471	1.4715
Monthly average	66.88	61.59	58.73	53 82	50.21	63.92	64.64	65.10	64.65	60.10	57.11	75.02	.1533	4.6007
July 1-10	65.66	62.82	60.57	56.57	53.65	66.54	67.78	68.49	68.16	63.95	61 43	77.92	.1258	1.2585
July 11-20	71.11	67.68	64.24	59.50	55.74	71.85	62.41	73.72	73.45	65.84	61.48	65.24	.1464	1.4642
July 21-31	67.37	65.53	63.32	60.44	56.91	66.76	67.28	68.14	67.68	61.80	57.46	69.'8	.2020	2.2223
Monthly average	68.05	65.01	62.71	58.84	55.43	68.38	69.16	70.11	69.76	63.86	60.85	71.06	.1580	4.9452
August 1-6	68.59	64.94	62.58	60.06	57.09	68.09	69.35	70.18	69.71	62.65	58.14	65.92	.2337	1.4020
Average for season	66.84	62.64	59.81	55.03	52.12	65.71	66.50	67.84	66.73	61.09	56.30	67.38	.1708	12.9307

Temperature readings were taken at 7 a. m., 1 p. m., and 8 p. m. The average of these three readings was taken as the mean daily temperature.

TABLE VIII: SHOWING THE TRI-MONTHLY AND MONTHLY WEATHER AND CROP RECORD FOR 1898, FROM APRIL 1 TO SEPTEMBER 30.

DATE.	TEMPERATURE.			WEATHER.				Rainfall	Depth of Water Table	CONDITION OF SOIL.	CONDITION OF CROPS.
	Mean Maximum	Mean Minimum	Mean	Prevailing Winds	Number of Clear Days	Number of Partly Cloudy Days	Number of Cloudy Days				
	Deg. Fah.	Deg. Fah.	Deg. Fah.					Inches	Inches		
April 1-10	43.75	17.22	30.49	N	7	3	....	....	74.67	Frozen	....
April 11-20	61.89	27.60	44.75	S & N	4	3	3	....	75.50	Workable	First plowing on the 13th.
April 21-30	59.70	32.40	46.05	N & S	1	4	5	.88	74.25	Loose, dry, favorable	Wheat sown.
Monthly totals & avs.	53.69	26.40	40.05	N & S	12	10	8	.88	74.81	Favorable	Slow germination of seed.
May 1-10	63.40	32.70	48.05	N	6	3	1	1.58	72.50	Favorable	Wheat up; oats and barley sown.
May 11-20	65.20	36.10	51.15	N & E	5	1	4	.81	....	Dry to favorable	All grain up and fair growth of wheat.
May 21-31	70.12	48.32	59.22	N	3	4	4	1.00	....	Wet to favorable	Late crops planted; growth of grain slow.
Monthly totals & avs.	65.20	39.03	52.62	N & E	14	8	9	3.99	....	Favorable	Wheat well stooled, but a little backward in gro'th.
June 1-10	74.70	47.00	60.85	W & E	2	3	5	1.71	32.25	Very wet	Grain injured slightly by rain.
June 11-20	74.00	44.00	59.00	NW & S	6	2	2	....	43.50	Favorable	Grain making rapid and rank growth.
June 21-30	78.50	51.40	64.95	NW	4	4	2	.48	56.80	Dry to favorable	Rank growth of all grain; wheat 18 to 20 in. high.
Monthly totals & avs.	76.10	47.60	61.85	NW & SE	12	9	9	2.19	44.18	Wet to dry	All grain crops promising.

July 1-10	79.2	54.8	67.00	NW & SE	7	2	1	2.05	66.10	Wet to f'v'rble	Wheat heading.
July 11-20	84.65	58.9	71.78	S	10	1	....	.05	71.50	Favorable to dry	Promising; early barley cut; well filled.
July 21-31	78.9	53.0	65.95	N & S	5	4	1	.49	78.50	Dry	Rye and early oats cut; wheat filling well.
Monthly totals & avs.	80.9	55.3	68.10	SE & NW	22	7	2	2.59	72.03	Favorable to dry	A good crop of all grains assured.
August 1-10	81.7	50.5	66.10	S & NW	7	3	....	.56	85.00	Dry	Wheat harvest began on the 6th; length of straw 3½ to 4 ft; well filled.
August 11-20	80.25	48.6	64 43	N & S	10	....	....	.30	....	Dry	Harvest finished; threshing begun
August 21-31	78.91	50.18	64.55	NW & SE	5	5	1	1.98	....	Favorable	All grain heavy; yields large.
Monthly totals & avs.	80.28	49.76	65.02	NW & SE	22	8	1	2.84	....	Dry to favorable	Bountiful harvest.
September 1-10	70.4	41.4	55.90	NW & S	6	4	....	.09	....	Favorable	Medium heavy frost Sept. 8; killing frost Sept. 9.
September 11-20	72.85	43.4	58.13	S	6	2	2	.63	....	Favorable	Fodder corn cut.
September 21-30	74.45	44.7	59.58	S	9	....	1	.51	....	Favorable	Beginning of the harvest of the root crops.
Monthly totals & avs.	72.6	43.16	57.88	S & NW	21	6	3	1.23	....	Favorable	Corn crop immature; root crops fair.
Totals and averages for season	71.63	43.54	57.59	NW & SE	103	48	32	13.72	....	Favorable	Above the average in production.

Observations of temperature, weather and rainfall, were made by Prof. E. F. Ladd on the college grounds, but not in the field.

SUMMARY.

The following results are for the most part the averages obtained for two seasons trial and are not given as absolute conclusions.

1. Fall plowed land gave one bushel per acre heavier yield than spring plowing, as an average for seven years trial.
2. Wheat sown in drills and cultivated gave a yield of 10 bushels and 12 pounds less per acre than wheat sown in the ordinary way.
3. Ground plowed with the Secretary disk gang plow yielded 50 pounds less per acre than that plowed with an ordinary mouldboard plow.
4. Sub-soiled land gave an increase of 54 pounds per acre but at greater cost, making the net profits 42 cents less per acre upon sub-soiled land.
5. Harrowing land immediately after plowing gave an increase of 39 pounds per acre in yield and an increase in net profit of 25 cents per acre.
6. Land sub-surface packed gave 1 bushel and 6 pounds greater yield than land not packed and 61 cents greater net profit per acre.
7. Deep plowing gave 43 pounds greater yield per acre than shallow and 37 cents greater net profit.
8. Rolling and harrowing land after seeding gave an increase of 3 bushels and 11 pounds per acre in yield and $1.25 in net profit as a result of a single trial in the season of 1898.
9. Harrowing wheat one week after seeding caused an increase in yield of 2 bushels and 1 pound and an increase in net profit of 72 cents per acre.

J. H. SHEPPERD,
A. M. TEN EYCK.

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Rotation Plots.

Bulletin No. 39.

CROP REPORT FOR 1898.

1. Variety Tests; Thickness and Depth of Planting Grain, Forage and Root Crops.
2. Changing Seed Wheat.
3. Rotation of Crops.

Any farmer in the state can have the bulletins of the Station mailed to his address, free of charge, upon application.

Fargo, North Dakota, U. S. A.
April, 1899.

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GRAIN AND FORAGE CROPS.

The last crop report by this Station which obtained general circulation was made for the year 1895 and was published in Bulletin No. 23.

The records of the variety tests for 1896 were accidentally lost. The season of 1897 was so wet and the crops were injured so badly by standing water that very little reliable data can be gathered from the work for that year. The following report is, for the most part, on the crops grown in 1898, although the yields for former years together with the average yield for a series of years are included in some of the tables.

A GENERAL STATEMENT OF THE SOIL CONDITIONS ON THE TRIAL GROUNDS.

In regard to soil, treatment and other points, a few general statements are given in the following paragraphs. These conditions apply to all of the crops herein reported upon, and so will not need to be repeated for each crop discussed.

The soil is a deep, black loam, characteristic and typical of the Red River Valley in North Dakota. Forty acres of the Experiment Station grounds which is quite uniform, is devoted to the testing of varieties and to other crop experiments reported upon in this Bulletin. This forty acre field is divided into three divisions upon each of which crops are grown in the following rotation: Wheat—oats or barley—corn or potatoes—wheat. It will thus be seen that wheat always follows a cultivated crop. This system of rotation is arranged in such a manner that each of the three divisions of this forty acre field grows one of these crops each year.

For the crops of 1898, unless otherwise stated in the special discussion of a particular experiment, the following preparation was made: The ground was fall plowed; the plots were one-tenth of an acre in area; the alley-ways between the plots were one foot in width; all of the grain was sown with a Dowagaic shoe chain drill, in drill-rows six inches apart, the drill-rows extending east and west; all of the seed grain was treated with a solution of formalin to destroy the smut germs; all grain crops were harvested when ripe and were properly saved and threshed from the shock during the first half of September and were not materially damaged in any way.

WHEAT--A TRIAL OF VARIETIES.

In 1897 from 200 varieties of wheat which had been tested for five years at this Station, 20 varieties, (No's 23-200 inclusive see Table I) were chosen for further trial, being the ones which had given the best yields or which in points of yield and quality seemed to be the most valuable ones tried. In addition to these, 8 other varieties (No's 201-208 inclusive, see Table I) were sent to this Station by the Minnesota Experiment Station, making a total of 28 varieties tested in 1897.

In 1898, the above varieties were tested again together with 11 new ones. Ten of these (No's 209-218 inclusive, see Table I) were received from the Minnesota Experiment Station and one, a Russian variety was sent us by the United States Department of Agriculture. The ten varieties from the Minnesota Station were considered their best kinds. These aggregate 39 varieties in all which were grown in the trial in 1898. The ground as prepared for sowing was a little rough, having been the corn and potato ground in 1897, but was otherwise in a mellow, loose condition. Fall plowed ground in the spring of 1898 was a little too loose for rapid and complete germination of seed. The seed was sown April 28th and 29th at the rate of five pecks of dry wheat per acre.

On May 11th, the wheat was coming up nicely, a good stand showing on all plots. Notes taken June 27th.read: "The wheat on all of the plots is thrifty and has a good color. A few days of damp, warm weather recently has caused a development of rust, especially upon the earlier varieties or those most advanced in growth. At this date, the wheat on the different plots ranges from 18 to 30 inches in height. A variety of Russian wheat, (No. 219, see Table I) has made the greatest growth and is nearest the heading stage.

"An examination of the different varieties revealed two or perhaps three different types of wheat which are quite distinct. They may be described as follows: The first is a type which represents the hard fife wheats. It has light stools, and upright stems with short leaves which extend straight upward. It is not rank in growth and its foliage is spare, but of a dark green color. The second is a type which represents the softer wheats, such as the blue stem varieties and White Russian. This type has heavy stools with large spreading stems, rank growth, abundant foliage, and long drooping leaves which have a light, but healthful color. The third type is about half way between the other two and is a rank growing type which otherwise resembles fife wheat. Such were Glyndon (711), Advance, and Preston." (See Table I.)

Harvesting began July 30th and was completed August 9th. Table I gives in a concise form the description and record of each variety grown in 1898.

All varieties of wheat which are given a number enclosed by parenthesis were secured by the Minnesota Experiment Station from Russia or some other European source in 1890. The North Dakota Experiment Station obtained the seed from the Minnesota Station in 1892, but it had been grown in the Red River Valley in Minnesota by that Station in 1890 and 1891. In 1893 seed of these varieties, together with some other kinds was sent to the Minnesota Station by the North Dakota Station, and in 1896, '97 and '98 the Minnesota Station sent this Station samples of seed of some of the same varieties which they had previously secured from us. It will thus be seen that many of the varieties here reported upon are different samples of seed from the same variety, and a few are new varieties originated by selecting seed from the best plants of some of the old varieties.

In Table II the thirteen varieties which gave the highest yields in 1898. are given without duplicating any of the original kinds:

These varieties are more fully described in Table I. It will be seen that eight of the thirteen highest yielding kinds are marked "selected," which means that they are the result of a selection of the best plants from an old variety while Preston is also the product of a selection made by Prof. Saunders of the Central Experiment Station, Ottawa, Canada. The ones marked "selected" are really new or at least improved varieties of wheat which were originated by Prof. Hays of the Minnesota Station, by carefully selecting the most thrifty and largest yielding plants in the field. Each of these improved varieties was originated from a single plant started at this Station. The seed of this plant was sown and the five best resulting plants were selected as seed for the next year. This process was kept up for two or three years, when all of the seed from the crop which the five best plants produced was preserved for propagation and the new variety was established.

This Station and the Minnesota Station have co-operated in this matter of seed breeding and improvement as has been stated in the previous publications of each Station. The Minnesota Station has, however, been able to accomplish much more than this Station, by reason of better facilities and more money to expend in the work of seed improvement. The Minnesota Station has been liberal in the matter of co-operation and has given us the advantage of the results from their extensive seed wheat selection in return for such products as our limited work has produced. The plan is to continue the co-operation in the future as in the past.

It will be noticed that White Russian wheat, which stands third in the list as regards yield, has a low grade. This wheat is a thrifty grower and a heavy yielder, but it is generally softer than either the fife or blue stem kinds.

TABLE I.--VARIETIES OF WHEAT—CROP OF 1898.

Bulletin No.	VARIETY.	WHERE FROM, ORIGINALLY.	First crop grown at this station.	Days maturing.	Straw	Chaff	Hds.	GRAIN			
					Length at maturity.	Bearded, smooth or velvety.	Length.	Grade.	Hard wheat.	Weight per bushel.	Yield per acre.
			year		in.		in.		per ct	lb.	bn.
23	Red Fife	Agricultural College, Guelph, Ontario, Canada	1892	100	42	smooth	2⅛	1 N	90	59¾	32.00
50	Wellman's Fife	Experiment farm, Brandon, Manitoba	1892	102	44	"	2⅝	1 N	95	60¼	34.33
66	Experiment Station Fife	J. B. Power, Power, N. D	1892	102	45	"	2⅝	1 N	85	60¾	34.66
120	Glyndon (774)	Russia, through Minn. Ex. Station	1892	102	44	"	2⅝	1 N	90	60½	32.96
146	Bolton's Blue Stem	Thos. Bolton, Park River, N. D	1893	103	49	velvety	3	1 N	80	59	36.43
148	C. & C. Land Co's Fife	C. & C. Land Co., Jamestown, N. D	1894	102	46	smooth	2¾	1 N	90	60¼	36.19
149	White Russian, Minnesota No. 19	Minnesota Experiment Station	1896	102	48	"	3	2 N	25	58¾	38.12
151	Glyndon (711), Minnesota No. 105	Minn. Ex. Sta. same as N. D. No. 105*	1896	103	46	"	2¾	1 N	85	60¼	35.06
155	Bolton's Blue Stem, Minnesota No. 146	Minn. Ex. Station same as Bolton's B. S. No. 146	1896	103	47	velvety	3	1 N	80	59½	35.58
176	Glyndon (811) Fife	Minn. Ex. Station same as N. D. No. 123*	1896	103	45	smooth	2⅞	1 N	95	60	36 99
178	†Selected Power's Fife	Minn. Ex Sta. original seed same as N. D. No. 66	1896	103	45	"	2⅞	1 N	97	60	36.14
180	†Selected Power's Fife	Minn. Ex. Sta. original seed same as N. D. No 66	1896	102	45	"	2⅝	1 N	97	60¾	35.98
181	†Selected Power's Fife	Minn. Ex. Sta. original seed same as N. D. No. 66	1896	102	44	"	2½	1 N	90	59½	35.62
194	Advance	Prof. Wm. Saunders, Ottawa, Canada, in 1889, through Minn Ex. Station	1896	102	44	bearded	2½	1 N	80	58¾	32.96
195	Crown	Prof. Wm. Saunders, Ottawa, Canada, in 1894, through Minn. Ex. Station	1896	100	45	"	2⅜	1 N	75	60	33.53
196	Stanley	Prof. Wm. Saunders, Ottawa, Canada, in 1894, through Minn. Ex. Station	1896	100	43	smooth	2¼	2 N	80	58½	32.08
197	Preston	Prof. Wm Saunders, Ottawa, Canada, in 1894, through Minn. Ex. Station	1896	99	44	bearded	2⅜	1 N	75	60¾	37.88

198	Percy	Prof. Wm. Saunders, Ottawa, Canada, in 1894, through Minn. Ex Station	1896	98	41	smooth	2⅜	1 N	90	57¾	31.35
199	Square Headed wheat from Sicily	Originally from Sicily	1896	97	40	"	1¼	2 N	12	50½	20.47
200	Red Bearded May wheat		1896	96	35	bearded	2½	rejt.		52⅛	21.03
201	Blount's Hybride No. 15, Minnesota No. 13	Minn. Ex. Station, originated by Prof. Blount, at Colorado Ex. Station	1897	102	41	smooth	2⅛	2 N	50	60½	27.53
202	White Russian, Minnesota No. 19	Minn. Ex. Station, same as N. D. No. 149	1897	102	42	"	2¾	1 N	80	60	29.98
203	Haynes' Blue Stem, Minnesota No. 51	*Minn. Ex. Station, same as N. D. No 51. Orig't'd by L. H. Haynes, Fargo	1897	103	44	velvety	2⅞	1 N	90	60½	33.45
204	Power's Fife, Minnesota No. 66	Minn. Ex. Station, same as N. D. No. 66.	1897	102	42	smooth	2⅝	1 N	80	61½	31 92
205	Rio Grande, Minnesota No. 72	Minnesota Experiment Station	1897	101	44	bearded	3⅜	1 N	90	61¾	31.72
206	Glyndon (711), Minnesota No. 105	*Minn. Ex. Station, same as N. D. No. 105	1897	101	42	smooth	2⅝	1 N	95	61	32.03
207	Glyndon (753), Minnesota No. 116	*Minn. Ex. Station, same as N. D. No. 116	1897	102	41	"	2⅝	1 N	85	60½	33.09
208	Bolton's Blue Stem, Minnesota No. 146	Minn. Ex. Station, same as N. D. No. 146	1897	103	46	velvety	3	1 N	95	61	35.31
209	†Selected Power's Fife, Minnesota No. 149	Minn. Ex. Station, original seed same as Power's Fife, N. D. No. 66	1898	101	39	smooth	2⅛	1 N	98	61	33.77
210	†Selected Glyndon (818) Fife, Minnesota No. 155	Minn. Ex. Station, original seed same as Glyndon (818), N. D. 129	1898	101	42	"	2¼	1 N	95	61	35.22
211	†Selected Glyndon (753) Fife, Minnesota No. 157	Minn. Ex. Station, original seed same as Glyndon (753), N. D. No. 116	1898	102	44	"	2⅜	1 N	95	61	36.51
212	†Selected Glyndon (811) Fife, Minnesota No. 163	Minn. Ex. Station, original seed same as Glyndon (811), N. D. No. 123	1898	102	46	"	2¾	1 N	90	61⅛	37.23
213	†Selected Glyndon (761) Fife, Minnesota No. 167	Minn. Ex. Station, original seed same as Glyndon (761), N. D. 117	1898	102	43	"	2⅜	2 N	50	61	34.74
214	†Selected Haynes' Blue Stem, Minnesota No. 169	Minn. Ex. Station, original seed same as Haynes' Blue Stem, N. D. No. 51	1898	102	45	velvety	3	1 N	85	60¼	38.44
215	†Selected Rysting's Fife, Minnesota No. 171	Minn. Ex. Station, original seed from Jens Rysting, Buxton, N. D.	1898	99	46	smooth	2¾	1 N	85	60¼	38.12
216	†Selected McKendry's Fife, Minnesota No. 181	Minn. Ex. Sta., o'g'nal seed from Assiniboine Val., thr'h J. C. McKendry, Fargo	1898	99	43	"	3	1 N	80	60¼	35.54
217	Advance, Minnesota No. 185	Minn. Ex. Station same as N. D. No. 194	1898	98	45	bearded	2⅝	2 N	80	58¼	33.04
218	Preston, Minnesota No. 188	Minn. Ex. Station same as N. D. No. 197	1898	98	45	"	2¾	2 N	75	61	36.51
219	Russian Wheat	Russia, through U. S. Department of Agriculture	1898	92	43	"	2⅜	rejt.		46	17.68

*These varieties were all originally grown at this station, (see bulletins Nos. 10, 11 and 23.) The Minnesota Experiment Station secured the seed from this station in 1893.

†These selections were all made from single plants grown at Power, N. D. in 1892, by Prof. W. M. Hays, now of the Minnesota Experiment Station, and the seed was taken by him to that Station in 1893.

TABLE II.—VARIETIES OF WHEAT GIVING LARGEST YIELDS IN 1898.

Bulletin No.	VARIETY.	Grade	Hard wheat.	Weight per bushel.	Yield per acre.
			per ct	lbs	bu.
214	Selected Haynes Blue Stem, Minnesota No 169	1 N	85	60¼	38.44
215	Selected Rysting's Fife, Minnesota No. 171....	1 N	85	60¼	38.12
149	White Russian, Minnesota No. 19..................	2 N	25	58¾	38.12
197	Preston..	1 N	75	60¾	37.88
212	Selected Glyndon (811) Fife, Minnesota No.163	1 N	90	61½	37.23
176	Glyndon (811) Fife..	1 N	95	60	36.99
211	Selected Glyndon (753) Fife, Minnesota No. 157	1 N	95	61	36 51
146	Bolton's Blue Stem..	1 N	80	59	36.43
148	C. & C. Land Co.'s Fife...............................	1 N	90	60¼	36 19
178	Selected Power's Fife....................................	1 N	97	60	36.14
180	Selected Power's Fife....................................	1 N	97	60¾	35.98
181	Selected Power's Fife....................................	1 N	90	59½	35.62
216	Selected McKendry's Fife, Minnesota No. 181	1 N	80	60¼	35 54

From the varieties of wheat grown at this Station for a series of years, the three which have ranked highest as an average for seven years' trial, and the four which have ranked highest for five years have been selected and the data obtained from them is given in Tables III and IV.

TABLE III.—VARIETIES OF WHEAT TESTED FOR FIVE YEARS, 1893, '94, '95, '97 AND '98.

Bulletin No.	VARIETY.	GRADE.				Hard wheat, average.	Yield per acre, average for 5 years.
		1893.	1894.	1895.	1898.		
						per ct.	bu.
146	Bolton's Blue Stem	1 N	1 N	1 N	1 N	80	23.70
66	N. D. Experiment Station Fife	1 H	1 H	1 H	1 N	85	22.87
120	Glyndon (774)	1 H	1 H	1 H	1 N	89	22.66
23	Red Fife	1 H	1 H	1 H	1 N	85	22.35

TABLE IV.—VARIETIES OF WHEAT TESTED FOR SEVEN YEARS, 1892–1898 INCLUSIVE.

Bulletin No.	VARIETY.	GRADE.					Hard wheat, average.	Yield per acre, average for 7 years.
		1892.	1893.	1894.	1895.	1898.		
							per ct.	bu.
66	N. D. Experiment Station Fife	1 N	1 H	1 H	1 H	1 N	89	22.19
23	Red Fife	1 N	1 H	1 H	1 H	1 N	86	21.67
120	Glyndon (774)	1 N	1 H	1 H	1 H	1 N	88	21.61

The result of seven years of trial ranks North Dakota Experiment Station Fife 66 (an improved strain from the variety originally known as Power's Fife) at the head, when the combined points of yield and grade are considered.

The result from five years trial rank Bolton's Blue Stem at the head of the list but includes the three varieties which rank first as a result of seven years of trial. It is readily seen that the longer the time and the great the number of yields summarized the more the results can be depended upon and the greater is the evidence of superiority. A considerable quantity of the seed of the variety known as Experiment Station 66, is in the hands of farmers at the present time, fifty lots of it having been sold to as many farmers, representing about three-fourths that number of communities in this state. This department expects to have the seed of a variety obtained by selection, which has proved superior to the Experiment Station 66 variety, ready for sale in small lots in the spring of 1900.

CHANGING SEED WHEAT.

Nearly all of the old varieties of wheat *tested at this Station have been discarded. In 1896, only six of the most valuable varieties out of those which had been tested five years or more, were retained, viz., No's 23, 50, 66, 120, 146 and 148. (See Table I.)

This Station and the Minnesota Station have co-operated in the variety testing of wheat, and have frequently exchanged seed of promising kinds. When either Station has sent varieties to the other it has usually sent a few of its best performing kinds. In 1896 the Minnesota Station sent us a number of varieties of wheat, several of which were seed of varieties which that Station had secured from this Station in 1893. In 1897, we received eight more kinds from the Minnesota Station, some of which were seed of our old varieties while three samples were the same varieties which we had received the year previous, viz., White Russian, Glyndon (711) and Bolton's Blue Stem. (See Table I.)

In 1898, we received from the Minnesota Station, two varieties, Advance and Preston, which we had also obtained from them in 1897. Two of the old varieties which were returned from Minnesota in 1897, Power's Fife and Bolton's Blue Stem,we were still growing from our old seed.

It will thus be seen that we have in these trials of varieties an excellent test of the results from changing seed wheat, in which there can be no doubt but that the varieties are descended from samples of the same original seed.

Table V presents the data obtained upon this point:

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*See Bulletins No's 10, 11 and 23 of this Station.

TABLE V.—SHOWING DECREASE IN YIELD DUE TO CHANGE OF SEED WHEAT.

VARIETY.	Date of crop.	Seed home grown since 1892—yield per acre.	Seed received from Minnesota in 1896—yield per acre.	Seed received from Minnesota in 1897—yield per acre.	Seed received from Minnesota in 1898—yield per acre.	Difference in yield between the old and new seed of the same variety.	Average decrease in yield for the two years.
	year.	bu.	bu	bu.	bu.	bu.	bu.
Power's Fife	1897	10.67	....	5.17	....	5.50	4.12
Power's Fife	1898	34.66	....	31.92	....	2.74	
Bolton's Blue Stem	1897	10.00	....	9.17	....	0.73	0.93
Bolton's Blue Stem	1898	36.43	....	35.31	.. ..	1.12	
White Russian	1897	....	8.17	6.00	....	2.17	5.16
White Russian	1898	....	38.12	29.98	....	8.14	
Glyndon (711)	1897	....	8.50	7.00	....	1.50	2.27
Glyndon (711)	1898	....	35.06	32.03	....	3.03	
Advance	1897	....	....	....	....	....	....
Advance	1898	....	....	32.96	33.04	0.08	
Preston	1897	....	....	....	... .	....	....
Preston	1898	....	....	37.88	36.51	1.37	

In every case except one, a change of seed has given a diminished yield of from one to eight bushels per acre. This decrease is very marked in both the first and second crops grown from the new seed. The average decrease in yield for the two years in the four cases given, varies from one to five bushels per acre. The following tabular statements are derived from Table V:

	Bushels Per Acre
Average yield of wheat from seed home grown continuously	22.67
Average yield of wheat from seed which had taken a vacation for three years in Minnesota, first and second crops	18.55
Difference in favor of the old seed	4.12
Average yield of wheat from Minnesota seed grown in North Dakota one year	21.88
Average yield of wheat from Minnesota seed direct from Minnesota	20.64
Difference in favor of the older seed	1.24
Average yield of wheat from Minnesota seed grown in North Dakota two years	36.59
Average yield of wheat from Minnesota seed grown in North Dakota one year	31.00
Difference in favor of the older seed	5.59

There appears to be no regularly marked difference in the grade or weight per bushel. (See Table I.)

The difference in vitality and productiveness of the seed can not be the result of the different systems of cultivation at the two Stations. The grain is sown by the ordinary method, in drills six inches apart. Wild oats and mustard are pulled and besides that, the crop receives no extra care and our methods are practically identical with the practices of the Minnesota Station.

The soil of the Minnesota Experiment Station farm is lighter and poorer in quality natively and not so good wheat land as the soil at this Station. The climate is also different in some respects, being on the whole a little warmer with perhaps more moisture. Seed wheat brought from that locality is evidently not well suited to our soil and climate.

Changing seed every few years is a common practice among farmers. In the spring of 1898, according to a local paper, one elevator company in the city of Fargo, shipped in 4,000 bushels of wheat from Minnesota, to exchange and sell at a high price to the farmers of North Dakota. The farmers think that it paid them to buy this wheat for seed, the product being better and the yield heavier than they obtained from home grown seed. The wheat is often the same variety as the one discarded, in many cases having been introduced into Minnesota from North Dakota. While the farmers of North Dakota are buying Minnesota seed wheat, the farmers of Minnesota are buying seed wheat grown in North Dakota.

The data obtained indicates that it would not pay to change seed wheat from the vicinity of St. Paul to the Red River Valley if a change was the only thing accomplished. If a better variety or a better strain of the same variety was obtained it might be well worth the cost. We have received a few improved varieties of wheat from the Minnesota Station which have given us the largest yields recorded for the season of 1898, as will be noted in Tables I and II, but they were from varieties improved by breeding or selection.

The above data in regard to changing seed wheat represents a case where a change or vacation for the seed was the only factor, the selection of seed and manner of growing having been the same.

Trials of a change of seed have been started in co-operative experiments with three other Stations in as many states and at a future time results from a more varied and extended study will be reported.

DIFFERENT QUANTITIES OF SEED WHEAT PER ACRE.

In this trial wheat was seeded at eight different thicknesses per acre, viz., 3, 4, 4½, 5, 5½, 6, 7, and 8 pecks per acre. These figures perhaps represent the extreme range from the thinnest to the thickest seeding which practical men advocate and practice.

The loss of our results for 1896 and the drowning of the grain in 1897 has left us results for the year 1898 and from earlier trials covering two seasons.

Experiment Station Fife 66 wheat was used in this trial for 1898 and received no treatment for smut. The plots were sown April 29th, and the grain was coming up on all of the plots on May 11th.

On June 27th the variation in the appearance or growth of the wheat on the several plots was not marked except in points of thickness. On the thinner sown plots the stools were larger and the stems coarser than on the thick sown plots. This wheat was harvested August 8th and 9th.

The results for 1898 are given in Table VI. The yields in similar trials made in 1892 and '93 are also included and the average yields for the several trials are given:

TABLE VI.—AMOUNT OF SEED WHEAT PER ACRE.

					GRAIN, 1898.					YIELD PER ACRE.			
										1893.	1893.	1892.	
Plot number.	Seed sown per acre	Stand.	Height.	Length of heads.	Grade.	Hard wheat.	Weight per bushel.	Yield per acre.	Fife wheat.	Blue Stem wheat.	Fife wheat.	Average yield for all trials.
	pks.		in.	in.		per ct	lbs.	bu.	bu.	bu.	bu.	bu.
1	3	fair.	42	2⅝	1 N	95	60¾	32.88	9.80	12.50	12.70	16.97
2	4	very fair.	42	2⅝	"	90	60¼	33.61	10.60	14.50	10.50	17.30
3	4½	very fair.	42	2½	"	90	60	32.71	10.70	16.50	14.60	18.63
4	5	good.	42	2⅞	"	92½	60½	32.43	11.30	15.50	13.40	18.16
5	5½	good.	42	2⅜	"	90	60¾	36.14	10.95	16.23	15.90	19.81
6	6	thick.	42	2⅛	"	82½	60¼	35.50	10.60	16.95	11.30	18.54
7	7	thick.	43	2½	"	95	60	36.76	....	....	....	....
8	8	very thick.	42	2¼	"	95	60	33.01	....	....	....	....

In the above trials five and one-half pecks of seed wheat per acre gave the largest average yield for the several trials.

DIFFERENT DEPTHS OF SOWING WHEAT.

In this trial part of the ground was spring plowed and part fall plowed. The plots ran crosswise of the plowing which made the conditions similar. The ground was well prepared and was in good condition when sown April 29th. The depths of sowing are only approximate. The shoes of the drill were set at the different depths by placing the lever of the drill, each notch in the holder corresponding to three-fourths of an inch in depth.

The variety of wheat used in this trial was Experiment Station Fife 66. The rate of sowing was five and one-half pecks per acre. The seed was not treated for smut.

On May 11th, the wheat was coming up on plots 1, 2, 3 and 4, in which the depths of sowing ranged from one to three inches, respectively. Plot 4 was a little later than the others. The wheat was three to four days later in coming up on plots 5, and 6, i. e., those sown three and one-half and four inches deep respectively. The season was favorable for the germination of shallow sown wheat. A good rain fell April 30th, the day after the grain was sown.

On June 27th, the deepest sown wheat seemed to show the rankest growth, having an average height of twenty-two inches, while the shallow sown wheat had only made a growth of eighteen to nineteen inches in height. The stand on the shallow sown plots was poorer than that on the deep sown ones. The wheat was harvested August 9th. Table VII gives the results of the trial:

TABLE VII.—DIFFERENT DEPTHS OF SOWING WHEAT, 1898.

Plot No.	Depth of sowing.	Stand.	Height.	Length of heads.	GRAIN.			
					Grade.	Hard wheat.	Weight per bushel.	Yield per acre.
	in.		in.	in.		per ct.	lbs.	bu.
1	¾-1	fair	40	2¼	1 N	95	60¼	29.69
2	1½-2	fairly good	41	2¼	"	92½	60	30.64
3	2¼	good	42	2⅛	"	97	59¾	31.55
4	3	"	42	2⅛	"	97½	60	30.45
5	3½-3¾	"	41	2¼	"	95	60¼	30.51
6	4-4½	"	43	2⅜	"	97½	60	29.91

The greatest yield in this trial was obtained from wheat sown at a depth of two and one-fourth inches, and the shallowest and deepest sowing yielded least, but the difference in yield at the several depths of sowing was slight.

VARIETIES OF OATS.

In 1897, thirteen varieties of oats, (No.'s 2 to 33 inclusive, see Table X) were selected from the forty original kinds which had been grown by this Station for five years. They were selected for further trial on account of their superior yielding qualities. Lee oats No. 41 was tested in 1897 for the first time.

In 1898, these varieties were grown and one new one, No. 42, a Russian variety received from the United States Department of Agriculture was added to the list which made a total of fifteen varieties tested in 1898. All but three of these varieties were sown on April 29th and 30th. On account of rain intervening, the remaining varieties, No.'s 33, 41 and 42, were sown three days later. The rate of sowing was two bushels per acre; the depth three inches.

Notes taken June 27th read as follows: "The plots are free from weeds and the oats have made rapid growth. The height varies from eighteen to twenty-three inches on different plots. All of the varieties have been injured some by rust; the earlier kinds being most affected. The general appearance is favorable for a good crop."

Harvesting began on July 30th and continued until August 10th. Some varieties were injured considerably by rust as is shown in the tabular statement below. A few varieties were slightly lodged but not enough to occasion a loss in yield. The varieties which lodged in all cases were the ones with long straw. The length of straw is noted in Table VIII.

Table VIII gives the results of the test of 1898 together with a short description of each of the several varietes. The yields for 1897 are also included, and the average yield for the two years is given.

For the convenience of the reader the five varieties giving the highest yields are tabulated separately, and in the order of their yields. They are as follows:

Bulletin No	VARIETY.	Yield per acre—bushels.	Harvest season.
37	Great Northern	75.81	late
36	Early Gotham	75.08	medium
26	Tartarian	74 87	late
12	Race Horse	74.87	late
29	Giant Yellow	74.44	late

The varieties which have been tested for five years (1893, '94, '95, '96 and '98, and have given the largest average yields for that time are as follows:

Bulletin No.	VARIETY.	Yield per acre—bushels.	Harvest season.
26	Tartarian	55.15	late
12	Race Horse	53.40	late
2	Archangel	52.10	early
19	Black Beauty	51.08	early

TABLE VIII VARIETIES OF OATS.

Plot number.	VARIETY.	WHERE FROM.	First crop grown at this Station.	Days maturing.	STRAW. Length.	STRAW. Rust.	HEADS. Form.	HEADS. Length.	BERRY. Color.	BERRY. Size.	BERRY. Shape.	GRAIN. Weight per bushel.	GRAIN. Yield per acre. 1898.	GRAIN. Yield per acre, 1897.	GRAIN. Average yield for two years.
			year.		in.	per ct.		in.				lbs.	bu.	bu.	bu.
2	Archangel	College Farm.................	1892	92	43	15	whorled branches	8	white	medium	medium short plump	37	70 82	64.10	67.46
34	Oats from N. Y.	Minn. Ex. Sta....	1894	92	52	60	whorled branches	9	white	medium small	short	33¼	60.47	49.50	54.99
38	North Star	Minn. Ex. Sta............. ..	1894	94	45	15	whorled branches	8	white	medium	medium	32¾	70.38	48.50	59.44
39	Early White Russian	Minn. Ex. Sta......	1894	103	47	30	side branches	10	white	medium	long plump	35¼	70.38	37.20	53 79
40	Lincoln............ ..	Minn. Ex. Sta., orig'ly from Angell	1894	97	45	25	whorled branches	8	white	medium large	long plump	33	68.86	53.50	61.18
35	American White Banner......	Minn. Ex. Sta., orig'ly from Maule.................	1894	97	44	40	whorled branches	8	white	medium large	long plump	32½	72 41	58.50	65.45
36	Early Gotham	Minn. Ex. Sta.........	1894	96	43	35	whorled branches	7	white	medium large	long plump	33	75.08	47.00	61.04
37	Great Northern...	Minn. Ex. Sta., orig'ly from Salzer	1894	102	48	15	side branches	9	white	large	long	36	75.81	47.50	61.65
12	Race Horse......	Maule	1893	102	48	15	side branches	9	white	medium	long plump	36¾	74.87	47 50	61.19
29	Giant Yellow......	Angell............................	1893	102	47	20	side branches	8	white black yellow	large medium	long plump	33¾	74.44	41.90	58.17
26	Tartarian	Angell.	1893	102	48	15	side branches	10	white	large	long plump	35¾	74.87	54 10	64.49
19	Black Beauty......	N. B. & G. Co.........	1893	91	38	40	whorled branches	7	black	medium large	long plump	33¼	65.47	45.30	55.39
33	Fenton's Rust Proof	Rush River, N. D.........	1894	103	48	10	side branches	9	white	large	long plump	36	62.19	38.10	55.15
41	Lee Oats......	J. T. Lee, Fingal, N. D.	1897	99	44	75	side branches	6	black	medium large	long plump	28½	52.66	34.60	43.63
42	Russian	Russia, by U. S. Dept. of Agriculture.............	1898	99	45	40	whorled branches	8	yellow white	medium	long slim	32½	71.47	....	....

TABLE IX.—VARIETIES OF OATS GROWN IN SMALL PLOTS.

Bulletin No.	VARIETY.	WHERE FROM.	Days maturing.	STRAW.		HEADS.		BERRY.			GRAIN.	
				Length.	Rust.	Form.	Length.	Size.	Shape.	Color.	Weight per bushel.	Remarks.
				in.	per ct.		in.				lbs.	
43	Danish Island	W. Atlee Burpee & Co...	103	44	10	whorled branches	8	long	plump	white and yellow	33⅛	Promises to be a good yielder.
44	Nameless White .	Salzer Seed Co..........	93	39	10	whorled branches	8½	medium short	plump	white	38⅛	A heavy yielder; promising.
45	Silver Mine..... ...	Salzer Seed Co...	100	44	10	whorled branches	8	medium long	plump	white	36	Promising; a good yielder.
46	Selected Black Beauty......	A Selection from Black Beauty No. 19.	101	44	40	whorled branches	8	medium long	fairly plump	black	30½	Better than the original.

A few new varieties of oats were tested in small plots in the plant nursery in 1898. The plots were only one-half to one and one-half square rods in area and the grain was cultivated in rows so that the yields are not comparable with those of the varities reported upon in Table VIII, which were given our regular field trial.

A descriptive record of the test of these newly obtained varieties is given in Table IX:

OATS—AMOUNT OF SEED PER ACRE.

The common White Russian variety of oats was used in this trial and the plots were sown May 2nd. The grain on all of the plots came up well. Notes taken on June 27th state that no marked difference in growth or color was noticeable at that time. The heavily seeded plots had a matted appearance and a stand thicker than that on the light sown plots. The stools were larger and the stems coarser on the light sown plots.

These oats were harvested August 12th. Table X gives the records and yields for 1898, the yield in a former trial made in 1892 and an average for the two trials:

TABLE X.—AMOUNT OF SEED PER ACRE—OATS.

Plot number.	Seed sown per acre.	Stand.	Straw.		Length of heads.	1898 Grain.		Yield per acre.	
			Length.	Rust.		Weight per bushel.	Yield per acre.	1892.	Average for the two trials.
	pecks.		in.	per ct.	in.	lbs.	bu.	bu.	bu.
1	5	rather thin	50	10	11	36½	75.81	49.00	62.41
2	6	fair	50	15	11	38¼	71.47	53.00	62.24
3	7	good	49	10	10	37½	69.88	54.60	62.24
4	8	good	49	5	10	38¼	71.98	55.30	63.64
5	8½	good	48	5	9½	38¼	70.82	....	....
6	9	good	48	5	9	37¼	72.70	56.30	64.50
7	9½	good	48	5	9	36	71.47	....	....
8	10	too thick	47	5	9	37	72 92	55.70	64.31
9	11	too thick	47	5	8	36	76.68	55.00	65.84

The results of the 1898 crop do not seem to show any regular relation between the amounts of seed sown and the yields. It will be noticed that the thin sown oats made the greatest growth both in height of straw and length of heads. There is very little difference in the weight of the grain per bushel, the thick sowing producing as heavy oats as the thin sown grain.

The trial made in 1892 shows a gradual increase in yield with the increase of seed up to nine pecks of seed per acre, while heavier seeding gave a decrease in yield.

The average yield for the two trials is in favor of thick sowing. These trials indicate that it is safer with this soil to sow a little more than two bushels of oats per acre.

DIFFERENT DEPTHS OF SOWING OATS.

White Russian oats were used in this trial and all plots were sown on May 2nd. The depths were only approximate as stated in the discussion upon depths of sowing wheat. The shallow sown oats came up first. Notes taken June 27th state that the shallow sown oats were more uneven in stand and growth. The oats on all plots were harvested August 12th.

Table XI gives the results of the trial:

TABLE XI.—DIFFERENT DEPTHS OF SOWING OATS.

Plot No.	Depth of sowing.	Stand.	STRAW.		Length of heads.	GRAIN.	
			Length.	Rust.		Weight per bu.	Yield per acre.
	inches		inches	per cent	inches	pounds	bushels
1	1	fair	50	10	10	36¾	72.27
2	1¾	good	48	10	10	36¾	66.62
3	2¼	"	48	10	10	37¼	65.03
4	3	"	48	5	10	37½	71.18
5	3¾	"	48	5	10	36½	71.25
6	4½	"	48	5	10	36¼	71.76

The season of 1898 was favorable to the growth of oats planted in any reasonable way. Plot I, the shallowest sowh, gave the best yield, but the plots sown at greater depths averaged better yields than did the shallow sown ones as a whole. The results favor sowing oats two to four inches deep.

VARIETIES OF BARLEY.

Ten varieties of barley were tested in the uniform field trial in 1898.

These were all new ones in so far as trials at this Station are concerned. The column marked "Where from" in the table indicates the source of the seed used.

The grain was sown May 3rd, at the rate of two bushels per acre. Notes taken June 27th read—"There is much difference in the appearance and growth of the different plots. The height varies from seventeen inches, in Culver's No. 30, to thirty inches in height with Mansury No. 25. There is also much difference in the leafiness and in the color of the foliage. The later maturing varieties in general show more abundant foliage and richer color. Several of the earlier varieties are heading at this date."

The harvesting of the varietes of barley began July 22nd and the last plot was cut August 6th. The column in the table marked "Days maturing" will indicate which varieties ripen early and which ripen late.

In Table XII the results of the trial are given together with a short description of each variety.

The five varieties ranking highest in yield are as follows:

Bulletin No.	VARIETY.	Yield per acre—bushels.	Harvest season.
28	Odessa, Minnesota No. 21	49.00	early
29	Bernard s, Minnesota No. 28	48.54	early
25	Mansury, Minnesota No. 6.	48.03	early
24	Salzer's Silver King	47.84	early
27	French Chevalier, Minnesota No. 15	47.51	early

In 1897, seven kinds of barley were selected from among the varieties tested at this Station for five years or more, (see Bulletin No. 23), which seemed to show merit entitling them to further trial. The whole crop of that year was drowned out, and no seed was saved. A little of the old seed from the crop of 1896 had been preserved and was sown in small plots in 1898. Sufficient seed was obtained from it to continue the regular test again in 1899. Some of these varieties are the same as those secured in 1898 from the Minnesota Experiment Station.

TABLE XII.—VARIETIES OF BARLEY.

Bulletin number.	VARIETY.	WHERE FROM.	Days maturing.	Length of straw.	HEADS.			BERRY.			GRAIN.	
					Length.	Number of rows.	Length of beards.	Size.	Color.	Quality.	Weight per bushel.	Yield per acre.
				in.	in.		in.				lbs.	bu.
22	Russian.......	Russia, through U. S. Dept. of Agriculture..	82	32	1⅞	6	3¼	large	bright yellow	hard plump	48	42.19
23	Dakota Silver Beardless.......		83	35	1⅞	6	....	large	dark coffee colored	hard shrunken	43⅛	36.92
24	Salzer's Silver King.............	Salzer Seed Co	82	34	2¼	6	3½	large	bright yellow	hard plump	48	47 84
25	Minnesota No. 6, Mansury...	Minn. Experiment Station..	80	32	2¼	6	3¼	large	coffee colored	hard plump	49	48.03
26	Minnesota No. 7, Champion of Vermont	Minn. Experiment Station..	83	30	2¼	2	4	large	coffee colored	hard plump	50¼	45.72
27	Minnesota No. 15. French Chevalier..................	Minn. Experiment Station..	92	31	2¾	2	5	large	coffee colored	hard plump	50¾	47.51
28	Minnesota No. 21, Odessa	Minn. Experiment Station..	83	31	1⅞	6	4	large	yellow	hard plump	48	49.00
29	Minnesota No. 28, Bernard's..	Minn. Experiment Station..	80	30	2	6	4	large	coffee colored	hard plump	49¾	48.54
30	Minnesota No. 86, Culver's...	Minn Experiment Station..	95	32	3½	2	7	large	bright nearly white	hard plump	50	41.91
31	Minnesota No. 100, Houston's Golden Queen	Minn Experiment Station..	80	32	2¼	6	3⅛	large	yellow	hard plump	47¼	43.79

Of these seven varieties those which have given the best yields for four years, 1893 to 1896 inclusive, are as follows:

Bulletin No.	VARIETY	Yield per acre—bushels.	Harvest season
7	Mansury	43.00	medium
12	Highland Scotch	39.70	late
10	Highland Chief	38.00	medium
4	Champion of Vermont	37.90	medium
6	Chevalier	37.50	medium late

BARLEY—AMOUNT OF SEED PER ACRE.

The variety of barley used in this trial was Mansury No. 7. All of the plots were sown May 3rd at the rate of two bushels per acre.

Table XIII gives the results of the test for 1898. The yields for a similar test made in 1893 are also included together with the average yield for the two trials.

TABLE XIII.—AMOUNT OF SEED PER ACRE—BARLEY.

Plot No.	Seed sown per acre.	Stand.	Length of straw.	Length of heads.	GRAIN.		Yield per acre.	
					Weight per bushel.	Yield per acre.	1893.	Average for the two trials.
	pecks.		in.	in.	lbs.	bu.	bu.	bu.
1	4	fair	30	2⅛	49¼	43.50	....	....
2	6	very fair	30	2	48½	43.98	21.60	32.79
3	5	fair	30	2	49¼	41.57	....	....
4	6½	good	30	2	48½	42.82	....	....
5	7	good	30	2	49½	44.75	18.10	31.43
6	7½	good	30	2	50½	51.50	....	....
7	8	good	29	1¾	50½	40.03	22.50	31.27
8	8½	good	28	1⅔	49½	43.50	....	....
9	9	good	28	1⅔	....	44.27	20.10	32.19
10	10	good	28	1½	49	45.24	24.10	34.67
11	11	thick	28	1½	49	45.14	18.10	31.67

In the crop of 1898, seven to ten pecks of seed per acre gave the best yields. The highest yield, (51½ bushels per acre), occurring where seven and one-half pecks of seed was used, while ten pecks of seed gave the next highest yield. In 1893, ten pecks gave the best yield, while eight pecks ranked second. The average yields for the two trials favor eight to ten pecks per acre as the best amounts of seed to sow.

BARLEY—SOWING AT DIFFERENT DEPTHS.

The variety of seed used, and the date and manner of sowing, were the same as those given in the trial of different amounts of seed per acre, except that the rate of seeding was uniformly two bushels per acre.

The depths are only approximate as already described in the discussion of similar experiments with wheat and oats, but are in all cases as near the given depths as the drill could be regulated to run.

Table XIV. gives the results of the trial.

TABLE XIV.—DIFFERENT DEPTHS OF SOWING BARLEY.

Plot number.	Depth of sowing.	Stand.	Length of straw.	Length of heads.	GRAIN.	
					Weight per bushel.	Yield per acre.
	in.		in.	in.	lbs.	bu.
1	4½	good	30	2	49	39.45
2	3¾	good	30	2	49	42.24
3	3	good	30	2	48½	47.16
4	2¼	good	30	2	49	43.02
5	1¾	good	30	2	48½	40.99
6	1	fair	30	2	47½	40.79

This single trial seems to favor three inches as the depth for sowing barley.

VARIETIES OF SPELT.

Spelt, otherwise called speltz, spilts and spelch, is a Russian grain, said to be hardy, productive and an excellent grain and fodder plant. It resembles barley in many respects, the heads are two-rowed and bearded, and the grain looks somewhat like common barley. It differs from barley, however, in that each hull contains two berries. The hulls of spelt are much larger than those of barley, and its weight per bushel is nearly the same as that of oats. Botanically, it is considered a form of wheat. The berries, to which the husk adheres in threshing, resemble those of wheat when hulled.

It is said to have been introduced into this State by Russian settlers living in McIntosh County. It has attracted favorable attention in that region during the past few years. Mr. Geo. A. Welch of Bismarck, N. D., kindly furnished this Station with a supply of the seed in 1897, and also gave us some helpful information concerning it. It is claimed by the producers of spelt that it withstands drouth exceptionally well, and that it produces a good yield. They also claim that it is equal to barley as a feed for stock.

The seed obtained from Mr. Welch was sown May 7th, 1897. Flooding of the plots by the heavy rainfall which occurred in June of that season injured it very much and largely vitiated the results. The yield was, however, under these adverse conditions, 29.2 bushels (29 bu. 6½ lbs.) per acre. Barley which grew beside the spelt that seacon made a complete failure.

Seed of the North Dakota spelt was sown, besides a sample obtained from Russia, in 1898, and proved to be very much superior to it in yield. The grain was sown May 3rd at the rate of six and one-half pecks per acre.

The result of the test of the two varieties of seed is shown in the following table:

Bulletin number.	VARIETY.	WHERE FROM.	First crop.	Days maturing	Height.	Length of heads.	Weight per bushel	Yield per acre.
			year.		in.	in.	lbs.	bu.
305	Russian, old seed......	G. A. Welch, Bismarck, N. D.	1897	95	42	2	39¼	73 06
106	Russian, new seed....	Russia, through U. S. Dept. of Agriculture...	1898	88	45	2	24	33.35

The yield is calculated at 32 lbs. per bushel, the same as for oats. It will be noticed that the North Dakota seed gave much the larger yield and the heavier weight per bushel.

In pounds of grain per acre, spelt from the North Dakota seed, No. 305, was found to compare as follows with the average yield of the ten varieties of barley which grew beside it:

Spelt from North Dakota seed, yield.............	2,338	lbs. per acre.
Barley, average for ten varieties, yield	2,325½	lbs. per acre.
Difference	12½	lbs. per acre.

It will thus be seen that there was no practical difference in the yield of barley and spelt in our trial for 1898.

As the spelt came from the separator it was noticed that a considerable portion of it had been hulled, possibly because it was somewhat overripe when harvested. Sorting and weighing shows that 16 and 1-3 per cent of the grain, by weight, was hulled by the separator.

The hulled spelt was separated from a portion of the grain which was then hulled by hand. The proportion of hulls to grain in this sample was as follows:

Pounds of hulls in 100 lbs. of spelt	21.18 lbs.
Pounds of hulled kernels in 100 lbs. of spelt	78.82 lbs.

In order to learn the feeding value of this grain, samples were analized by the Chemical Department at this Station. Prof. E. F. Ladd reports the results of the analysis as follows:

CONSTITUENTS.	Whole spelt.	Hulled spelt.	Hulls.
	per ct.	per ct.	per ct.
Water	8.88	10.03	4.62
Ash	4.33	1.84	13.58
Fat	2 55	2.80	1.64
Protein	9.81	11 69	2 81
Crude fiber	10.09	2.94	36.68
Carbohydrates	64.34	70.70	40.67
Totals	100 00	100.00	100 00

The small amount of protein, or muscle forming material and the high percentage of ash and crude fiber in the hulls indicate that their actual food value is small. As a coarse food to dilute the rich grain and cause it to be better masticated and digested by stock, the hulls are doubtless of much value. The composition of whole spelt and hulled spelt is compared with that of oats, barley and wheat in the following table:

CONSTITUENTS.	Whole spelt.	Barley.	Oats	Wheat.	Whole spelt.
	per ct.	per ct.	per ct.	per et.	per ct.
Water	8.88	10 9	11.0	10.5	10.03
Ash	4.33	2.4	3.0	1.8	1.84
Fat	2.55	1.8	5.0	2.1	2.80
Protein	9 81	12.4	11.8	11.9	11.69
Crude Fiber	10 09	2.7	9.5	1 8	2.94
Carbohydrates	64.34	69.8	59.7	71.9	70.70
Totals	100.00	100.0	100.0	100 0	100.00

The percentages of composition for barley, oats and wheat are taken from Prof. W. A. Henry's book on "Feeds and Feeding," and are the averages of a large number of analyses, while the composition of the spelt is the result of a single analysis. The comparison shows that hulled spelt is very similar in composition to wheat. The percentage of digestible nutrients has not been determined, but the composition of whole spelt seems to indicate that its feeding value is a little less than that of barley or oats.

The new variety, No. 105, made a rank growth, but blighted badly. The Russian sample of spelt is evidently not well suited to this soil and climate, but the grain tends to readily adapt itself to the new conditions. This is another instance where home grown seed is the hardier and more productive.

RYE.

Winter rye has never been successfully grown at this Station. Spring rye has been sown a number of times, but has usually made a poor growth and a relatively poor yield. A trial plot of common spring rye produced a yield of 24 bushels per acre in 1898. The heads were not well filled and the grain was a little light, weighing only 52½ pounds per bushel.

A new variety of spring rye, known as St. John rye, bought of John A. Salzer Seed Co., was sown in 1898. It made a thin and scattered growth, but produced some well-filled heads and a heavy, plump grain. It was not grown on a large enough scale to warrant the drawing of definite conclusions as to its merits.

FLAX.

Three varieties of flax were grown at this Station in 1898. The seed of one of these (No. 306, Table XV,) was received from J. C. Swan, Minneapolis, Minn. This seed was imported by Mr. Swan direct from Russia, and is said to be a valuable variety for the production of fiber. No direct fiber tests were made with it last season.

Table XV. gives the record of each of these varieties for 1898:

TABLE XV.—VARIETIES OF FLAX.

Bulletin number.	VARIETY.	WHERE FROM.	Date planted.	Seed sown per acre.	Days maturing.	Height.	Number of bolls per head.	Grain. Weight per bushel.	Grain. Yield per acre.	Straw or fiber—yield per acre
				pks.		in.	av.	lbs.	bu.	lbs.
155	Russian Flax	J. A. Salzer Seed Co.	June 10	...	89	24	36	.....	... ...	....
306	Fiber Flax...	J. C. Swan	May 31	3	92	32	8	54¼	17.78	2,769
307	Common	Fargo, N. D.........	May 31	2	77	27	16	53¾	19.84	2,546

Russian flax, No. 155, was sown in rows and cultivated. This probably accounts for its short growth and large number of heads.

BUCKWHEAT.

Five varieties of buckwheat were tested at this Station in 1898. The seed was sown on June 15th, at the rate of about six pecks per acre, which proved to be too thick seeding. The ground was clean and in good condition. The seed germinated quickly and the plants made a rapid growth. All varieties were in bloom July 22d, the earlier varieties being white with blossoms upon that date.

The indications for a heavy crop were good during the last of July, but the heads did not fill well, many of the kernels being light and the yields were not large. The wind occasioned considerable loss in the field by causing the grain to shell before the crop was harvested. The earliest maturing variety was cut August 31st, the latest, September 8th. The days maturing and other data are given in Table XVI.

VARIETIES OF CORN.

The varieties of corn were planted with an ordinary horse corn planter in check rows three feet and eight inches by three feet apart. The planter dropped from two to five kernels in a hill.

Two rows 430 feet long were planted, of each variety, on May 27th and 28th. Wet cold weather followed the date of planting. Water stood on the field in places and the corn did not start growth well. The missing hills were replanted June 13th and 14th. The field was cultivated four times between June 14th and July 22nd.

None of this corn had reached full maturity when killed by frost Sept. 8th. All of the varieties were cut and shocked in the field Sept. 9th and 10th. A bundle of the green fodder from each variety was weighed when the corn was cut. This bundle was preserved and weighed again when dry. From these two weights, the yield of green fodder was determined.

From October 10th to 24th the corn fodder was hauled in and weighed, and the corn was husked and weighed separately. The fodder was not well cured at that time. Samples were kept and weighed again three months later, when thoroughly cured. From these weights the percentage of loss was found and the actual yield of air dry fodder, per acre, was calculated. The air dry weight of the corn (grain) was found in the same manner.

The record of the varieties tested in 1898 is given in Table XVII.

TABLE XVI.—VARIETIES OF BUCKWHEAT.

Record No.	VARIETY.	WHERE FROM.	Days maturing.	Height.	BERRY.		Yield per acre.	REMARKS.
					Color.	Size.		
				in.			bu.	
104	Russian	U. S. Dept. of Agriculture	77	30	brown	medium	25.94	Ripened unevenly; earliest, promising.
141	Silver Hull	W. Atlee Burpee & Co.	82	36	silver gray	small	19.26	Poorly filled; quality fair.
142	New Japanese	W. Atlee Burpee & Co	87	36	brown	large	20.31	Better filled; quality fair.
151	Calcuta	John A. Salzer Seed Co.	81	36	silver gray	small	22.87	Shelled badly; quality fair.
153	Common	John A. Salzer Seed Co.	86	37	dark gray brown	large	19.26	Shelled badly; quality fair.

TABLE XVII.—VARIETIES OF CORN.

Record No.	VARIETY.	Class.	WHERE FROM.	Stage of maturity at frost, Sept. 5th.	Average number of stalks per hill.	Height of stalks.	Height of ears.	YIELD PER ACRE. Green fodder.	Cured fodder.	Corn in ear.
						ft.	in.	tons-lbs.	tons-lbs.	bu-lbs
111	Gehu	yellow flint	Oscar H. Will & Co	hard to dough	4	3¾	6 to 15	....	2·248	25·41
112	Will's Dakota	white flint	Oscar H. Will & Co	hard to dough	4	3½	4 to 12	7-214	2-338	27·54
113	Northwestern Dent	red dent	Oscar H Will & Co	dough to hard	3½	4¾	12 to 24	8-910	2-1014	27-59
114	Pride of the North	yellow dent	Northrup, King & Co.	dough	3	6½	24 to 42	9-1531	2·1263	15·54
115	Smut Nose	yellow flint	Northrup, King & Co	hard to dough	4	5⅓	18 to 30	....	3-633	17·53
116	King Philip	red flint	Northrup, King & Co.	dough	4	5½	18 to 26	9·115	3-90	18-69
117	Mercer	yellow flint	Northrup, King & Co.	hard to dough	4	5½	18 to 30	10-1093	3·1250	....
118	N. K. & Co.'s Triumph	yellow flint	Northrup, King & Co.	milk to dough	4	5⅓	18 to 24	8·751	3-60	23-43
119	Longfellow	yellow flint	Northrup, King & Co.	milk to dough	4	5½	18 to 24	9·737	2·1695	19-21
146	Early Canadian Yellow Field	yellow dent	W. Atlee Burpee & Co.	dough to milk	5	5¼	16 to 30	9·422	3·375	21·10
156	Earliest Ripe	white dent	John A. Salzer Seed Co.	dough to hard	1½	4½	6 to 20	4·576	1-866	13·3
157	Huron Dent	yellow dent	John A. Salzer Seed Co.	milk	2	6	24 to 48	12·336	3-660	14·43
158	Early Giant White Dent	white dent	John A. Salzer Seed Co.	milk	3	6½	30 to 48	8·1897	2-1885	15.1
159	Nameless Yellow Dent	yellow dent	John A. Salzer Seed Co	silk to milk	3	7⅓	36 to 54	8-203	2·1187	4-41
261	Minnesota Small Dent	yellow dent	J. P. Chisholm	dough	4	5¼	11 to 24	6·811	2·241	21·55
275	Northwestern Golden Dent	yellow dent	Magill & Co.	silk to milk	4	6½	38 to 56	8·1897	2·1246	6·6
287	Boley's Rea	white flint	College Farm	hard to dough	4	4¼	4 to 18	5·587	1·951	11·59

From the above table it may be learned that the five varieties nearest ripe when killed by frost, in 1898, were as follows: Gehu, Will's Dakota, Smut Nose, Mercer and Boley's Rea.

The varieties yielding at the rate of more than three tons of fodder per acre rank as follows: Mercer, Huron Dent, Smut Nose, Early Canadian Yellow Field, N. K. & Co.'s Triumph and King Philip. The varieties yielding heaviest in grain were as follows: Northwestern Dent, Will's Dakota, Gehu, N. K. & Co.'s Triumph, Minnesota Small Dent and Early Canadian Field. It may be noted that in the above table the yield of grain for the Mercer variety is not given; by reason of an error the yield of grain, for this kind, was not correctly reported for 1898. In trials for the years 1894, '95 and '96, however, the average yield of grain from the Mercer corn was 37½ bushels and of fodder 2 tons and 660 lbs. per acre. It ripened during each of the years mentioned.

The records of this Station also show that King Philip, Northwestern Dent and Gehu corn all ripened in 1896 and 1897. The height of the ears from the ground is an important matter. Of the varieties grown in the 1898 trial, Gehu, Will's Dakota, Earliest Ripe and Minnesota Rea put out the ears very low, while Northwestern Dent and Minnesota Small Dent have the ears higher although not so high as desirable. The remaining kinds all throw out the ears at a reasonable height above the ground.

Six other varieties were tried in small plots in the plant nursey. The following statement will perhaps answer for these varieties. The absolute yield of grain and fodder were recorded, but owing to the small size of the plots and to the fact that the soil in the nursery is better than that where the other varieties were grown, the yields are not comparable and would perhaps be misleading. For these reasons, they are not included in the tabular statement. Table XVIII give the summarized results:

Of the varieties of corn described in Table XVIII, Will's Acme and Minnesota No. 13, are the only ones which seem to be early enough to be worth further trial in North Dakota. Both kinds made a good showing in the production of fodder and ears.

TABLE XVIII.—VARIETIES OF CORN TESTED IN SMALL PLOTS.

Record No.	Variety.	Class.	WHERE FROM.	Stage of maturity at frost, Sept. 8.	Height of stalks.	Height of ears.
					ft.	in.
260	Will's Acme............	mixed dent	Oscar H. Will & Co.	hard to dough	5	12 to 30
143	White Cap Field......	white cap dent	W. Atlee Burpee & Co....................	milk	5¼	30 to 40
144	Waterloo Extra Early....................	yellow dent	W. Atlee Burpee & Co........................	milk	6¼	36 to 48
145	King of the Earlies.	yellow dent	W. Atlee Burpee & Co	dough to milk	6½	30 to 48
160	Brazilian Flour Field....	white dent	John A. Salzer Seed Co	tassel to silk	7 to 8	48 to 60
192	Minnesota No. 13...	yellow dent	Minn. Exper'mt Sta.	dough to hard	6¼	20 to 40

KAFFIR CORN AND SORGHUM.

Yellow Millo Maize, White Kaffir Corn, Red Kaffir Corn and Branching Doura, were all grown on our trial grounds during the season of 1898, but made light yields of fodder, and with the exception of Branching Doura, failed to reach the heading stage before frost came. Branching Doura was heading when killed by frost. 1898 was the fifth year's trial of this class of forage plants and they have never matured for us in any season. The trial during other years has included Jerusalem or desert corn, teosinte, jurra, dhoura and rice corn. Early Amber sugar cane grown on our trial grounds in 1898 reached the heading stage before the frost of Sept. 8th occurred. None of these fodder plants can compete with Indian corn as the varieties now stand.

THICKNESS OF PLANTING CORN.

A series of experiments in thickness of planting corn for fodder have been carried on for three years. All of the plots in this test were planted May 24th and 25th. Pride of the North from home grown seed was used in the trial. This strain has been grown on the Experiment Station grounds for several years and is earlier and hardier than No.114 reported in Table XVII. The treatment and cultivation of the corn in this experiment was the same as that already noted under varieties. The corn was cut Sept. 10th, and the yields were determined in the manner described in the variety trial.

BROADCASTING VERSUS DRILLING.

In this experiment the corn seeded broadcast was sown at a medium rate and harrowed in. The drilled corn was planted with a Dowagiac shoe chain drill. The drill was set in the notch indicated for sowing two bushels of oats per acre. This dropped the kernels six to ten inches apart in the row. In order to get the required distance between the drill rows, the extra grain holes were plugged.

The plots were about one-tenth of an acre in area. Plots 1, 2 and 3, (sown broadcast, sown in drills six inches apart and sown in drills twelve inches apart), received no cultivation and no weeding. The other plots were cultivated and kept free from weeds. Table XIX gives the record of the results of this experiment:

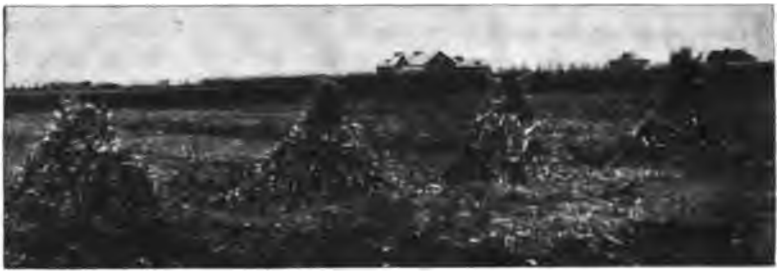
TABLE XIX - BROADCASTING VERSUS DRILLING CORN.

Plot No.	How planted.	Stand.	Height of stalks.	Stage of maturity at frost, Sept 8.	Yield per acre in 1898.		
					Green fodder	Dry fodder.	Corn in ear.
			feet		tons lb.	tons lb.	bu. lb.
1	sown broadcast	very thick	3¼	hard	9 506	3 933	
2	in drills 6 in. apart	thick	3⅓	hard	11 1439	3 1800	
3	in drills 12 in. apart	good	3½	hard	13 262	3 400	
4	in drills 18 in. apart	good	4¾	hard to dough	12 468	3 800	25 51
5	in drills 24 in. apart	good	5¼	dough to hard	11 600	5 1536	27 43
6	in drills 30 in. apart	good	5¼	dough to hard	11 1052	3 1584	29 22
7	in drills 36 in. apart	good	5¾	dough to hard	8 57	3 1104	27 15
8	in drills 42 in apart	good	5½	dough to hard	8 253	3 368	27 3

The fodder from plots 1, 2 and 3 was fairly well cured when hauled in, Oct. 15th. There was very little corn (grain) in the broadcasted fodder, a little more in that planted in six-inch drills, and more still in that planted in twelve-inch drills. As shown in the table, the amount of grain and, by reason of it, the richness of the fodder gradually increases as the distance between the drill rows is increased, up to 24 inches This distance between drills has also given the largest yield of fodder. The yield of grain is slightly greater from the 30-inch drills.

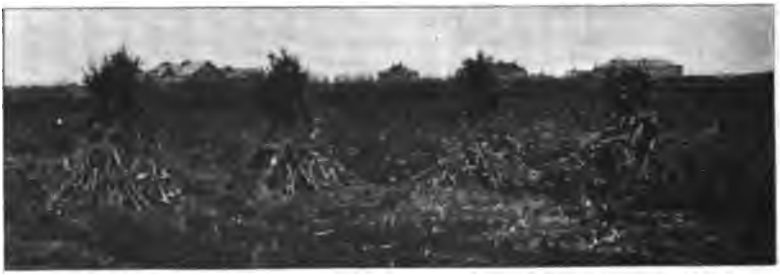
Figures 2 and 3 are the photo-engravings of shocks of corn fodder which were cut from one square rod of each plot respectively.

Fig. 2.—Shocks of Fodder Corn cut from one square rod of each plot respectively.



Plot 1, sown broadcast.		Plot 2, sown in drills 6 in. apart.		Plot 3, sown in drills 12 in. apart		Plot 4, sown in drills 18 in. apart.	
YIELD PER ACRE.							
Tons.	Pounds.	Tons.	Pounds.	Tons.	Pounds.	Tons.	Pounds.
3	923	3	1,800	3	400	3	800

Fig. 3.—Shocks of Fodder Corn cut from one square rod of each plot respectively.



Plot 5, sown in drills 24 in. apart.		Plot 6, sown in drills 30 in apart.		Plot 7, sown in drills 36 in. apart.		Plot 8, sown in drills 42 in. apart.	
YIELD PER ACRE.							
Tons.	Pounds.	Tons.	Pounds.	Tons.	Pounds.	Tons.	Pounds.
5	1,536	3	1,584	3	1,104	3	368

THICKNESS OF PLANTING IN DRILL ROWS.

This corn was planted by hand, one kernel in a hill, at the required distance apart. Only one row (430 feet long), was planted in each trial plot. Table XX is a record of the results of the trial:

TABLE XX.—THICKNESS OF PLANTING CORN IN DRILL ROWS.

Plot No.	How planted.	Stand.	Height of stalks.	Stage of maturity at frost, Sept. 8.	Yield per acre.		
					Green fodder.	Cured fodder.	Corn in ear.
			feet.		tons. lbs.	tons. lbs.	bu. lbs.
9	3½ ft. by 6 in.	good	5½	dough to hard	7 1046	4	34 37
10	3½ ft. by 10 in.	good	5½	dough to hard	7 275	3 153	26 13
11	3½ ft. by 12 in.	good	5½	dough to hard	6 121	2 1903	24 53
12	3½ ft. by 14 in	good	5¼	dough to hard	5 278	2 555	21 63
13	3½ ft. by 16 in.	good	5½	dough to hard	5 541	1 1912	18 46
14	3½ ft. by 18 in.	good	5½	dough to hard	5 406	1 1970	16 44
15	3½ ft. by 24 in.	good	5¼	dough to hard	4 63	1 969	13 46
16	3½ ft. by 36 in.	good	5	dough to hard	3 1318	1 339	9 25

The highest yield of fodder and ears was made by the corn which was planted six inches apart in the drill row. Thinner planting gave a decrease in yield, both of fodder and corn.

NUMBER OF STALKS IN THE HILL.

In this experiment, the corn was planted by hand in hills, three and one-half feet by three feet apart, in checks, making rows both ways. The plots consisting of one row 430 feet long. Table XXI gives the results of the trial:

TABLE XXI.—NUMBER OF STALKS IN A HILL—CORN.

Plot No.	Number of stalks in a hill.	Stand.	Height of stalks.	Stage of maturity at frost, Sept. 8.	Yield per acre.					
					Green fodder.		Cured fodder.		Corn in ear.	
			feet		tons	lb.	tons	lb.	bu.	lb.
16	1	good	5	dough to hard	3	1318	1	386	9	25
17	2	good	5½	dough to hard	4	935	1	1574	19	11
18	3	good	5½	dough to hard	6	778	2	258	22	43
19	4	good	5½	dough to hard	10	905	2	1417	23	57
20	5	good	5½	dough to hard	6	1750	2	688	23	57
21	6	good	5½	dough to hard	6	1964	2	1417	26	63

The results of this trial indicate that the number of stalks in a hill, where the range is from three to six inclusive, does not materially affect the yield of either the fodder or the corn.

DEPTH OF PLANTING CORN.

In this experiment the corn was planted by hand. It was planted at the rate of three kernels in a hill, in rows three and one-half feet apart, the hills being three feet apart in the row. Only one row of each depth was planted. About 40 per cent of the corn planted six inches deep, and 25 per cent of that planted seven inches deep, came up. Not much difference was noticed in the stand of corn planted less than six inches deep. Table XXI gives the result of the trial:

TABLE XXII.—DEPTH OF PLANTING CORN.

Plot No.	Depth planted.	Stand.	Height of stalks.	Stage of maturity at frost, Sept. 8.	Yield per acre					
					Green fodder.		Dry fodder.		Corn in ear.	
	in.		feet.		tons.	lbs.	tons.	lbs.	bu.	lbs.
22	2	good	5⅛	dough to hard	5	250	1	1750	21	47
23	3	good	5¾	dough to hard	6	206	1	1958	21	30
24	4	good	5¾	dough to hard	5	1875	1	1750	17	10
25	5	good	5⅜	dough to hard	4	1472	1	1229	14	53
26	6	poor	5⅛	dough to hard	....		0	1771	9	20
27	7	very poor	5	dough to hard	....		0	1667	6	30

VARIETIES OF POTATOES.

On account of the wet weather in 1897, nearly all the varieties of potatoes were drowned out. The varieties planted in 1898 were from newly purchased seed, except No. 272 (see Table XXIII.), which was home grown, having been planted on high land in 1897.

The varieties of potatoes were planted by hand in rows three and one-half feet apart, and the hills were two feet apart in the row. One row 430 feet long was planted of each variety. The seed was cut with from one to three eyes in a piece, and one to two pieces were planted in each hill. The potatoes were planted May 23rd. The same weight of seed, 14½ pounds, was planted in each row, which is at the rate of seven bushels and 50 pounds per acre. The wet weather early in June injured the potatoes badly, and a poor stand was the result. These potatoes received good cultivation throughout the season, but were not hilled. The stand was so poor that the yield had to be determined by counting the hills dug. All of the varieties were dug on Sept. 28th. Each lot was weighed and sorted. The scabby and small potatoes were weighed and the percentage of each calculated. Table XXIII presents the data secured:

TABLE XXIII.—VARIETIES OF POTATOES.

Record No.	VARIETY.	FROM WHERE.	Stage of maturity at frost, Sept. 5.	Number of hills harvested.	Average size of tubers.	Shape.	Color.	Depth of eyes.	Fingers and toes.	Cooking qualities.		Yield per acre.	Marketable.	Small.	Scabby.
										Mealiness.	Flavor.				
									per cent	per cent	per cent	bu.	per cent	per cent	per cent
262	Early Andes.......	H. C. Marsh	ripe	41	medium	oval oblong	russet	medium	0	95	98	177.1	89.08	7.98	2 94
263	Early Dawn	H. C. Marsh	ripe	15	medium	oval oblong	russet	medium	2	90	95	146.3	72.22	5.56	22.22
264	Burpee's Extra Early	W. Atlee Burpee & Co................	not quite ripe	40	medium to small	long	light russet	deep	8	85	90	120.6	83.54	16.46	0.00
265	True Early Rose..	W. Atlee Burpee & Co..............	ripe	153	medium	long oval	russet	medium	1	92	93	81.8	73.53	9.41	17.06
266	Carman No. 1....	W. Atlee Burpee & Co................	not ripe	161	medium large	oval oblong	white	medium deep	1	80	85	105.7	63.76	9.31	26.93
267	Early Ohio	W. Atlee Burpee & Co................	ripe	39	medium	oval oblong	red russet	medium	5	93	94	70.4	82.35	11.76	5.88
268	Early Beauty of Hebron	W. Atlee Burpee & Co................	ripe	149	medium large	long oval	red russet	medium deep	1	95	95	167.2	77.00	15.42	7.58
269	Burpee's Superior	W. Atlee Burpee & Co................	not ripe	192	medium large	long oval	fleshy white	medium	3	90	90	153.4	87.34	7.38	5.28
270	Rural New Yorker No. 2...	W. Atlee Burpee & Co................	not ripe	174	medium large	oval oblong	white	medium	0	95	95	128.8	84.74	7.21	8.06
271	Six Weeks..........	John A. Salzer Seed Co..........	ripe	133	medium large	oval oblong	russet	medium deep	2	94	92	130.6	68.00	9 72	22.29
272	Early Ohio	Experiment Station Farm........	ripe	124	medium large	oval oblong	red russet	medium	1	96	98	131.5	84.65	8.35	7.00
273	World's Fair	L. L. Olds..........	not ripe	32	medium	oval oblong	white	shallow	0	80	75	111.8	95.72	4.28	0.00
274	Joseph	L. L. Olds......	not ripe	36	medium large	long irregular	red russet	deep	10	80	75	170.9	95.52	4.48	0.00

The season of 1898 was not a favorable one for the growth of root crops. All of the yields are small. Only the early potatoes ripened. The varieties ranking best in yield are as follows: Early Andes, Joseph, Early Beauty of Hebron, Burpee's Superior, Early Dawn, Early Ohio (home grown seed), and Six Weeks. Of these, Joseph and Burpee's Superior were not fully ripe.

THICKNESS OF PLANTING POTATOES.

In this experiment, the potatoes were planted by hand. The Early Ohio variety (home grown seed) was used. The seed was all cut alike, with from one to three eyes to the piece. Only one piece was planted in each hill. The depth of planting was from four to five inches. These potatoes were planted May 23rd. One row 430 feet long of each thickness constituted the area of the trial plots. The potatoes were injured by the wet weather, and the stand was poor. The yield was calculated from the number of hills dug. Table XXIV gives a tabulated record of the results of the trial:

TABLE XXIV.—THICKNESS OF PLANTING POTATOES.

Plot No.	How planted.	Number of pieces in a hill.	Number of hills harvest'd.	Yield per acre.	Market-able.	Small.	Scabby.
				bushels.	per cent.	per cent.	per cent.
1	3⅓ ft. by 10 in.	1	195	207.16	90.30	5. 8	3.89
2	3⅓ ft. by 12 in.	1	156	181.76	95.31	4.34	0.36
3	3⅓ ft. by 14 in.	1	186	166.67	94.58	3.61	1.81
4	3⅓ ft. by 16 in.	1	161	160.82	92.57	6.00	1.42
5	3⅓ ft. by 18 in.	1	140	156.85	95.71	4.29	0.00
6	3⅓ ft. by 20 in.	1	148	134.18	85.76	7.62	6.62
7	3⅓ ft. by 24 in.	1	103	117.39	89.19	6.98	3.83
8	3⅓ ft. by 30 in.	1	79	121.38	96.02	3.98	0.00
9	3⅓ ft. by 36 in.	1	68	94.55	96.27	3.82	0.00
10	3⅓ ft. by 24 in.	2	147	111.11	89.33	8.00	2.67
11	3⅓ ft. by 30 in.	2	109	110.45	89.89	6 50	3.61
12	3⅓ ft. by 36 in.	2	110	97.36	84.74	8.47	6.78

There is a general decrease in yield as the distance between the hills is increased. Doubling the amount of seed planted in a hill did not increase the yield, but it increased the percentage of small and scabby potatoes.

DEPTH OF PLANTING POTATOES.

Early Ohio potatoes (home grown seed) were planted in this trial and the seed was prepared in the manner described for the thickness of seeding trial. The seed was planted by hand, one piece in a hill, in rows three and one-half feet apart and the hills were two feet apart in the row.

All of the potatoes planted six inches or less deep came up well and made a fair stand. Those planted more than six inches deep came up very poorly. Table XXV gives a report of the experiment:

TABLE XXV.—DEPTH OF PLANTING POTATOES.

Plot No.	Depth planted.	Stand.	Number of hills harvested.	Yield per acre.	Market-able.	Small.	Scabby.
	inches.			bushels.	per cent.	per cent.	per cent.
1	3	fair	138	108.10	88.97	6.36	4.67
2	4	fair	133	119 82	85.52	6.90	7.59
3	5	fair	144	89.69	94 51	4.64	0.85
4	6	fair	121	108.33	92.00	5 60	2.50
5	7	very poor	52	93.29	98.88	1.12	0.00
6	8 to 9	very poor	47	89.23	98.06	1.94	0 00
7	10	very poor	43	97.52	92 96	6.40	0.64

This trial indicates that the best depth to plant potatoes in this soil is from four to five inches.

MANGELS.

A small plot of Mammouth Yellow Giant Mangels was sown during the season of 1898. The seed was planted with the Dowagiac grain drill in rows eighteen inches apart. The plants were thinned to from four to six inches apart in the row and were well cultivated and weeded. The yield was 13½ tons of beets to the acre. These roots are much relished by stock.

TABLE XXVI.—SHOWING PLAN OF ROTATION EXPERIMENTS AND RESULTS.

ROTATION OF CROPS.

The rotation trial started in 1892 has been carried on until the present time, with few interruptions. The alley ways between the plots have been seeded with grain of the same kind as that upon the adjoining plots, during the past two years, and that plan will be followed in future trials. A few plots were added to make a trial of flax as has been reported in one or two previous publications. These plots are one-third acre in extent, and are conducted as if they were so many separate farms, each under its own system of cropping. For detailed results of the trial see Table XXVI.

Table XXVII gives the summarized results which are in most cases the averages for one or more trial plots which have been given the same general system of cropping although the crops grown are not always identical.

Stating the above results in a summarized form and using the yield on the wheat continuously plots as a basis for comparison, gives the following:

Wheat after summer fallow gave 5 bu., 1 lb., (43 per cent) greater yield the first year; 4 bu., 45 lbs., (24 per cent) increase the second year, and 1 bu., 36 lbs., (7 per cent) of increase the third year.

Wheat after cultivated crops, corn, peas, rape, potatoes and mangels gave 6 bu., 18 lbs., (52 per cent) greater yield the first year; 6 bu., 24 lbs., (32¼ per cent) incease the second year, and no difference the third year. The first crop of wheat following timothy and clover two years gave 7 bu., 42 lbs., (33 per cent) heavier yield the first year; 4 bu., 30 lbs., (25½ per cent) the second year, and a yield of one bushel per acre less than the wheat continuously plots the third year.

Wheat following a crop of flax, as an average of two trials on the same plot, gave 2 bu., 30 lbs., (12½ per cent) heavier yield than the wheat continuously plots.

The second crop of wheat after a crop of flax gave, as an average of two trials on the same plot, 4 bu., 12 lbs., (26½ per cent) heavier yield than the wheat continuously plots.

Wheat grown on a plot which had produced three consecutive crops of flax, as the only change from wheat, gave 7 bu., 12 lbs., (48½ per cent) heavier yield than the wheat continuously plots. Flax grown continuously for three years, gave no indication of any bad result on the crops produced the second and third years, (see plot No. 30, Table XXVI.) Wheat after field peas gave an average of 5 bu., 18 lbs., (43¾ per cent) higher yield in two trials on a single plot, the first year and 4 bu., 47 lbs., (24 and 1-3 per cent) greater yield the second year. with no increase for the third year, when compared with the wheat continuously plots. Green manuring with field peas, tried on a single plot gave a loss in yield of 24 lbs.,

TABLE XXVII.—SUMMARIZED RESULTS OF ROTATION EXPERIMENTS.

PLOTS GROUPED.	YIELD IN BUSHELS PER ACRE.							
	Av. yield for 1893 and 1897	Av. yield for 1894 and 1 98	1893	1894	1895	1896	1897	1898
Wheat continuously, average for six plots...	12.10	19.86	9.40	19.60	23.30	16.00	14.80	20.95
First, second and third wheat crops after barren fallow, average for four plots.......	17.30	24.61	15.30	24.00	24.90	....	21.30	27.97
First, second and third wheat crops after cultivated crops; corn, peas, rape, potatoes and mangels, average for six plots....	18.40	26.26	16.50	24.80	23.30	....	20.20	27.83
First, second and third crops of wheat after millet, one plot........................	16.80	26.52	13.30	23.80	23.00	....	20.30	29.36
First, second and third crops of wheat after timothy and clover for two years, one plot	....	....	....	....	31.00	20.50	13.8	25.31
First crop of wheat after flax for one year, one plot........................	....	....	....	....	23.5	....	19.5	....
Second crop of wheat after flax for one year, one plot........................	....	....	....	....	....	19.20	....	....
First crop of wheat after flax for three years, one plot........................	....	....	....	....	....	....	22.00	....
Flax continuously for three years, one plot........................	....	10 92	....	9.50	12.60	12.60	....	12.34
First and second wheat crops after flax, followed by fallow, one plot....................	....	....	....	14 50	25 00	....	....	33.70
First, second and third wheat crops after field peas, one plot........................	17.40	24.64	14.40	23.50	23.00	....	20.40	25.77
First, second and third wheat crops after green manaring with field peas, one plot...	11.70	24.24	10.40	21.70	23.00	....	12.90	26.80
First, second and third wheat crops after manuring with millet, one plot........	15.60	25.88	14.10	22.80	23.50	....	17.00	29 00
First crop of wheat after potatoes, one plot........................	....	....	....	....	....	....	16.80	30.57

TABLE XXVIII.—SUMMARIZED RESULTS OF ROTATION EXPERIMENTS FOR FOUR YEARS—BEING ONE COMPLETE ROTATION.

METHOD OF ROTATION	'92	YIELD PER ACRE. '93	'94	'95	'96	Total wheat for 4 years	Average yield per acre when wheat was grown
	Treatment of crop	bu.	bu.	bu.	bu.	bu.	bu.
Wheat continuously.........	wheat	9.4	19.6	23.3	16.0	68.3	17.1
Fallow one year, wheat three years.....	fallow	15.3	24.0	24.9	fallow	64.2	21.4
Cultivated crop one year, wheat three years.................	cultivated crop	16.5	24.8	23.3	cultivated crop	64.6	21.5
Millet one year, wheat three years.	millet	13.3	23.8	23.0	millet	60.1	20.0
Field peas one year, wheat three years......	flax	14.4	23.5	23.0	field peas	60.9	20.3
Green manured with peas, one year, wheat three years..	manured green	10.4	21.7	23.0	green manured	55.1	18.4
Green manured with millet one year, wheat three years...	green manured	14.1	22.8	23.5	green manured	60.4	20.1

(3¼ per cent) the first year, a gain of 4 bu., 23 lbs., (22 per cent) the second year and a slight loss for the third year.

The first wheat crop after green manuring with millet gave as an average of two trials on a single plot, 3 bu., 24 lbs., (28 per cent) greater yield; the second crop was 6 bu., 6 lbs., (30 and 1-3 per cent) greater yield, while the third crop was practically the same as that from the wheat continuously plots.

Wheat following potatoes has been tested upon a single plot for two years and gave 2 bu., (13½ per cent) heavier yield the first year and 10 bu., 31 lbs., (52½ per cent) greater yield the second year than was obtained from the wheat continuously plots.

A summary has been made for the four year rotations showing in comparison what they produced during the four years of the trial which are now completed, without considering the yields for the additional years which constitute only one-half of a four year period. In Table XXVIII, the results are put into a form in which they are very commonly considered:

This tabular statement shows that the wheat continuously plots made an average yield of from one and a third to four and a half bushels less wheat per acre, when the plots were in wheat, than those plots did which had been given a change for one of the four seasons considered.

The land which was in wheat continuously produced a total of 3 bushels and 42 pounds per acre more wheat in the four years than the ground which had a cultivated crop for one year, while there was a still wider difference in the total yields from it and the plot which was summer fallowed one season. Without at this time making any calculation upon the cost per bushel of growing wheat and the relative cost and value of the cultivated crops produced, it is probably safe to assume that a greater profit will be had when 64 bushels and 42 pounds of wheat are produced in three crops than when 68 bushels and 18 pounds of wheat are produced in four crops.

The expense of plowing the land, of seeding and of the necessary seed wheat for a given acreage is identical. Harvesting in the matter of twine and the labor of shocking, together with the cost of threshing are all increased somowhat with the increase in crop. No discussion, at this time, need be made further than to call attention to these items, to bring to the mind of experienced persons the fact that they can not afford the extra expense of growing a crop of wheat for three and a half extra bushels or even for ten bushels of wheat which represents nearly the maximum difference found with the rotations tabulated. On well regulated farms a cultivated crop upon one fourth of the grain land can at least be made to pay for its cost. The above results indicate that cultivated crops give better returns in the following wheat crops than does the ordinary summer fallowing, and if the crop produced will pay for the growing, that summer fallowing is an expensive practice.

Tables showing the record of the weather in its relation to the growth and development of crops in 1898 are given in Bulletin No. 38 of this Station.

The report of grasses and other forage crops which have been tested at this Station will be found in Bulletin No. 40.

SUMMARY.

1. Of the 30 varieties of wheat tested in 1898, the two standing highest in grade and yield were Selected Haynes' Blue Stem, (No. 214), and Selected Rysting's Fife, (No. 215.) Both varieties were originated from single plants by careful selection.

2. As an average result from five years' trial, Bolton's Blue Stem, (No. 146), gave the highest average yield.

3. As an average result from seven years' trial, Experiment Station Fife 66 stands first in both yield and grade.

4 The data which have been obtained on the effect of changing seed wheat, indicates that nothing is gained by a change of seed if a change is the only thing accomplished. If a better variety, or a better strain of the same variety can be obtained, the change of seed may be well worth the cost.

5. Five and one-half pecks of seed wheat per acre gave the largest average yield for the several trials.

6. The depth of sowing wheat in 1898 had but slight effect upon the yield. Two to three inches seem to be the best depth.

7. Tartarian oats, (No. 26) stands at the head as the largest yielder in a five years' test.

8. The thickness of sowing oats, from five to ten pecks per acre respectively, had very little effect upon the yield of grain.

9 Oats sown three to four inches deep gave the best average yields last season

10. As the result of four years' trials, Mansury barley, (No. 7), has given the largest yield.

11. The results of a single trial favor three inches as the depth for sowing barley.

12. Trials with spelt indicate that it is equal to barley in yield, and it's chemical analysis shows that it is equal to barley or oats as a feed for stock. It is worthy of a trial by the farmers of our state.

13 Rye has not proved a profitable crop at this Station.

14. Early varieties of buckwheat may be grown with profit in the eastern part of North Dakota.

15. The season of 1898 was too short for the full maturing of even the earliest varieties of corn Gehu, Will's Acme, Will's Dakota, Mer-

cer, Smut Nose and Northwestern Dent are among the best varieties for this locality.

16. None of the varieties of kaffir corn have matured at this Station in any season. It cannot compete with Indian corn as the varieties now stand.

17. Corn sown broadcast gave a little lighter yield than that sown in six inch drills. The largest yield both of grain and fodder was obtained from the corn planted in drills 24 inches apart.

18. Corn planted in rows three and one-half feet apart and cultivated, gave the greatest yield of fodder and ears when planted one kernel in a hill and six inches apart in the row.

19. Corn planted more than five inches deep came up poorly. That planted two to four inches deep gave the best in 1898.

20. Only the earliest varieties of potatoes ripened in 1898. The results of a single trial, place Early Andes at the head in yield and equal to Early Ohio in quality and earliness of maturity.

21. Early potatoes planted in hills ten inches apart with the rows three and one-third feet apart gave the largest yield recorded last season. Doubling the amount of seed planted in a hill did not increase the yield but seemed to increase the percentage of small and scabby potatoes.

22. A single trial indicates that four to five inches is the best depth to plant potatoes in this soil and climate.

23. The results from a six years' trial in rotation of crops, show that it does not pay to raise wheat continuously. By rotating wheat with cultivated crops, larger yields are obtained and a better quality of wheat.

24. Land which produced three crops of wheat and one cultivated crop in a period of four years, gave almost as much wheat and more profitable returns than did the land which produced four crops of wheat in succession.

J. H. SHEPPERD.
A. M. TEN EYCK.

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 40.

GRASS AND FORAGE CROPS.

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Fargo, North Dakota, U. S. A.
April, 1899.

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GRASS AND FORAGE CROPS.

INTRODUCTION.

The demand for facts concerning the means of producing winter forage for stock as indicated by the vast number of inquiries received during the past three months and especially the interest manifested in Austrian Brome Grass has led to the publication of this bulletin. It gives the results of the limited study and observation upon this subject which it has been possible for this department of the Station to make during the past five years.

AUSTRIAN BROME GRASS.

Austrain Brome Grass, otherwise known as Hungarian Brome Grass and Awnless Brome Grass, the botanical name for which is Bromus inermis, comes from the interior region of Russia—known as the Steppes—a region similar to portions of North Dakota in point of rainfall and the degree of heat and cold which its surviving vegetation is forced to withstand. This grass was introduced into the United States and Canada by the Agricultural Experiment Stations. This Station has been growing Bromus inermis for eight years. During which time, we have learned many practical facts regarding the degree of success which may be expected from different methods of treating it under North Dakota conditions.

It is an early variety of grass, is very hardy and is not easily injured by either spring or fall frosts. It starts growth very early in the spring, before any of the other cultivated grasses on our grounds, and before the grasses upon the native prairies show any signs of life. It reaches a height of two to four feet, is leafy and forms a compact sod.

HAY FROM AUSTRIAN BROME GRASS.

The hay is of good quality, fully equaling timothy in palatability and in nutritive value. It should be cut for hay as soon as the blossoms have fallen.

After the hay crop has been taken off, a heavy growth of aftermath or second growth springs up, which furnishes a good supply of fall pasture. This second growth remains green and succulent into November and, if not fed off too closely, will supply fall pasture until it is covered with snow.

After furnishing three or four crops of hay, the sod thickens up too much for a good growth of stems. This thickening and failure to produce hay, occurs earlier, if the grass is seeded heavily at first. It also occurs sooner if the grass is allowed to ripen seed, than it does when it is cut for hay.

ITS VALUE FOR PASTURE.

After it has thickened up too much to produce a good crop of hay, it supplies an abundance of pasture, forming a compact sod and a heavy thick growth of leaves. If one desires to use it for pasture at once, it will be better to seed it thick, twenty-five pounds of seed per acre being a better rate than a less quantity. The grass seems to be very palatable to stock as is shown by the reports of persons who have had experience with it. At the Experimental Farms in Assiniboia and Manitoba, Canada, it has been used in a field way as the exclusive pasture for dairy cows and other stock, with good results. Experiments with the grass at this Station have shown that cattle are very fond of it and will leave a pasture of native grass for the Brome grass very quickly if given an opportunity to do so. In a forty acre pasture of timothy and clover containing two acres of this grass, it was fed off more closely than was the timothy, by milk cows which had the run of the entire field. The reports of persons, who have been selected to try this grass, under the varying conditions which occur in the different parts of this State, have stated that, in a number of cases, some pet animal found the spot and returned to it at such frequent intervals, that the trial was interfered with more or less, all of which indicates that it is palatable to the different classes of live stock.

METHOD OF SEEDING

Austrian Brome Grass seems to do best on rich moist land, but it is also successful on lighter soil with less moisture. It is able to withstand conditions which are quite dry, and produce a crop. It will probably succeed best on fall plowed land just as grain is found to succeed somewhat better on fall plowed ground. It can be sown as early as wheat is seeded, or it can be sown with success as late as the first of August, if the land is kept from drying out and from growing weeds by an occasional surface cultivation. Put the soil in good condition by harrowing with a peg-toothed harrow, or by the use of the disk or spring-toothed harrow as the condition of the land may demand. Ground which is in good condition for wheat is ready for Austrian Brome Grass. One or two persons have reported having successfully seeded it with a drill but I have found that method unsatisfactory. The seed is very light and chaffy, weighing only fourteen pounds to the bushel which makes it slow to feed through the drill. The common plan is to seed it broadcast by hand and harrow it in thoroughly with a peg-toothed harrow. Sow it at the rate of 18 to 20 pounds per acre. Sow it alone, i. e., without a nurse crop of any kind. It will not produce a crop of hay the first season and should only be pastured lightly in the summer or fall. Mow the weeds once or trice during the first season, setting the sickle bar four or five inches high.

HARVESTING AND THRESHING.

It is harvested with a binder the same as small grain and can be shocked in the same manner. It can be threshed with the common grain separator with the wind largely shut off. In threshing it at this Station, the whole sheaf was allowed to pass through the separator and in order to lose as little seed as possible, the wind was shut off so closely that the seed was not well cleaned. It was afterwards run through the fanning mill which reduced the bulk to about one-half the amount which came from the separator. It was then clean enough for marketing.

Prof. Hays of the Minnesota Experiment Station, reports harvesting the seed of Austrian Brome Grass with a binder, by running it very high so that he afterwards cut the lower portion of it for hay. He threshes it with a common grain separator.

Supt. Bedford of the Manitoba Experimental Farm, Brandon, reports threshing Austrian Brome Grass by holding the heads of the bundles in the cylinder of the separator until the seed was knocked off, when the straw was cast aside, instead of being allowed to run through the machine. This plan was adopted to prevent the seed from being carried over in the straw and wasted.

KILLING THE SOD.

This grass has shown such great promise and seed of it has been so scarce,that this Station has not felt like sacrificing enough of it to make a fair trial of destroying the sod in a field way. The Minnesota Experiment Station and the Manitoba Experimental Farm at Brandon, have given it thorough and successful trials and have settled the problem largely. It has been found at these stations that a crop of hay can be harvested and taken from the land and the sod plowed over soon afterward and backset in September and that at the latter date the grass will be dead. Supt. Bedford reports, however, that when the grass was allowed to ripen and was cut for seed and the sod plowed over, that it was not killed at the time of backsetting in the fall.

RESULTS FROM TRIALS MADE IN NORTH DAKOTA AND IN ADJOINING STATES AND PROVINCES.

Austrian Brome Grass has been grown at this Station, in small plots, for eight years, and has been grown in a field way for four seasons in succession. It has been deemed advisable to save all of our crop for seed each year and for that reason estimates must be given instead of absolute yields of hay. The first Brome Grass which was seeded in a field way was put in with oats for a nurse crop and the result was considered a failure. The following spring a mixture of timothy and red clover was sown on the same ground, and sprung up occupying about two-thirds of the ground the next year. The year following, the Brome Grass had possession of fully one-half of the land and the next season it made up about three-fourths of the crop. Another field seeded in 1895 yielded at the rate of about two tons per acre in 1896. In 1897 both fields of Brome Grass gave poor yields, probably owing to the extremely wet nature of the season. In 1898 a field sown in the spring of 1897, made an excellent stand and the yield of hay was estimated at from two to two and a fourth tons per acre; varying on the different portions of the field from one and a half to three tons per acre. This field is about six acres in area and was cut for seed. The yield of seed was 1,500 pounds, or at the rate of 250 pounds per acre. Seed of Austrian Brome Grass has been so placed that the grass is in the hands of farmers in all but two counties of the State and reports from them will be due later. Much of this seed will be sown this spring and results of a positive nature will not be obtained from it until the season of 1900.

Some persons who obtained seed of this grass from other sources have made reports upon it, the following of which were published in the Eight Annual Report of this Station. The annual reports have but a limited circulation, and for that reason the matter is reprinted here:

On the farm of Alexander Allin, at Fullerton, Dickey county, one acre of Austrian Brome Grass was sown in 1895. Mr. Allin reports a good stand and promising yields.

Mr. W. J. Hawk of Buffalo, Cass county, has had a small quantity of this grass growing for several seasons. He reports excellent results.

On the farm of H. S. Nichols, at Oakes, Dickey county, this grass has been tested for three seasons. Mr. Nichols says after three years' trial that he is well pleased with it and estimates his yield at one and a half tons per acre.

On the farm of Hon. Lyman R. Casey, in Stutsman county, this grass has been grown in an extended way for three or more years and it has given good results.

One of the best trials owing to its northwesterly location, comes from Williams county, on the farm of W. R. Gluyas. Mr. Gluyas has one hundred acres of this grass growing. He began by seeding three acres of it in 1892. During the last days of June, 1897, I viewed the fields of Mr. Guyas and made a number of notes. The result of this work, as per his statement and my observation, is as follows:

In 1892 he sowed three acres of land to Bromus inermis and as he had but a small package of seed, for which he had paid a high price, he seeded the ground at the rate of only three pounds per acre. I saw this old original plot and found it a perfect mat of leaves, so thick, in fact, that I pronounced it sod-bound. Not more than one-eighth of it had been able to head, and I estimated that the yield of hay would have been about three-fourths of a ton or a ton per acre. It would have made good pasture, however. The next season, (1893), Mr. Gluyas seeded about forty-five acres of this grass. Much of this 1893 seeding was made in the fall, as a matter of experiment, and perforce of circumstances. Twenty-three acres of this year's seeding was on land which had been plowed four inches deep, and was harrowed in. It was seeded at the rate of ten pounds per acre. That field is now too thick for either hay or seed, or, in other words, is badly sod-bound. I estimated that it would cut three-fourths of a ton of hay per acre. The remaining twenty-two acres was sown on stubble land without plowing. It carried enough growth to make about a half a ton of hay per acre, and Mr. Gluyas informed me that I viewed as good a growth as that field had produced in any season. The stand of grass was excelllent but short, and had the appearance of being sod-bound. In 1894 Mr. Gluyas seeded twenty-three acres of land to this grass. Eight acres of it was sown about July 10th, and I estimated that the yield of hay would be three tons per acre.

Anther field of five acres was sown in 1896. This piece of ground was seeded very heavy and had produced a crop of potatoes in 1895. I estimated the yield at two and a half to three tons per acre.

Mr. Gluyas also had a good test of the palatability of this grass for horses. In a small pasture lot some of the seed had accidentally been scattered over the native prairie sod. As a result about two square rods of ground was then covered with a good sod of Austrian Brome Grass and it extended off from the main body in arms and solitary bunches. Horses grazing in the pasture had cropped the Brome Grass close and had left the prairie grass around it, which was still green and in good condition.

The following additional reports were made during the season of 1898:

Mr.Chas. Lidstrom, Glen Ullin, Stark county, made the following report July 12th, 1898:

"The Austrian Brome Grass was sown May 1st, 1897, in rows eight inches apart, in a plot of three square rods. The ground was very dry when it was seeded, but rain fell on the 1st and 2nd of June so that the grass came up. The summer was unusually dry. The Brome Grass grew about six inches high by fall and when frost came it was eaten clear down to the ground. The soil was very dry, and I did not expect the grass to start growth in the spring. It came up, however, and stands now about a foot and a half high. It is growing in bunches that are quite thick in the bottom but which do not have much top, and few heads. It would now harvest a half ton per acre. It has not received any extra attention."

Mr. Geo. S. Roberts, Dawson, Kidder county, on July 5th, 1898, reported as follows:

"I have a piece of Bromus inermis 9 by 48 feet, on old land. The land has probably been under cultivation since 1886. I seeded the plot about the middle of May, 1897. The Brome Grass made a start and so did the pigeon grass. The Brome Grass was seeded by itself and no cultivation of any kind was given it. The pigeon grass and weeds were mowed down and raked off in August. In the fall the Brome Grass was making a good appearance and showing up green. A neighbor's horse, however, nipped it off, leaving it close shaved and bare for winter. It did not promise much this spring early. After it started my neighbor's sheep found the spot and took a great liking to Bromus inermis and kept it daily nipped off. After the sheep quit, it made another start, in May, and made wonderful progress in a short time. Today, (July 5), there is a rank thick stand of the grass looking luxurient and green; some of it headed out. I feel safe in saying it will cut hay at the rate of one ton per acre as it now stands. The difficulties this plot has had to contend with and its degree of success despite them, strongly impress me that it is a wonderful grass. The Brome Grass when seeded was put in drills north and south ten inches apart, today there is apparently a thick mat between the drills."

James Reid, Courtenay, Stutsman county, made the following report July 7th, 1898:

"I seeded the Brome Grass one year ago, without a nurse crop. The first year it was tall enough for good pasture. This year it would make two tons of hay per acre. I have a patch 27 by 54 feet, on old ground. I gave it no extra care. It was very full of weeds and I ran the mowing machine over it, and this year there is not a single weed in it. Stock seem to like it. In the fall, it was green long after all the prairie grass was dried up and this spring, it was green two weeks before the other grass."

O. O. Hovde, Jr., Hillsboro, Traill county, reported as follows on July 2nd, 1898:

"The Austrian Brome Grass was seeded May 15th, 1897, without a nurse crop. I put it on a piece of dark, clayey loam soil about four square rods in extent. It made a good growth the first season and produced a stand of about 85 or 90 per cent in the fall. It looks well now (July 2nd, '98), being very bushy at the bottom. It stands about two feet high and would produce about three tons of good hay per acre. It was seeded in drills about seven inches apart and has received neither hoeing nor cultivation of any kind. The weeds were cut once the first season. All things considered it looks very promising."

The Minnesota Station reports good results from trials with Austrian Brome Grass under drouthy conditions and also upon land which was flooded during a portion of the season.

The South Dakota Station reports good results from their trials with this grass.

The results from the Manitoba Experimental Farm are given in the following tabulated statement:

AUSTRIAN BROME GRASS IN MANITOBA.

Date	Crop	Yield of hay tons-lbs	Age of grass	How situated	Character of soil	How sown	Area in acres
1891	1st	2-1106	2 yrs.	Valley	Black loam	With grain	.10
1893	3d	1-333	4 yrs.	Valley	Black loam	With grain	.10
1894	4th	1668	5 yrs.	Valley	Black loam	With grain	.10
1895	2d	1-950	3 yrs.	Undulating	Sandy loam	On summer fallow	1.50
1896	2d	2-80	3 yrs.	Side hill	Sandy loam	With grain	1.25
1896	5th	2-359	6 yrs.	Valley	Sandy loam	With grain	.10
1896	2d	1-1252	3 yrs.	Undulating	Very gravelly soil	With grain	3.25
1897	2d	3-400	3 yrs.				

The Manitoba Experimental Farm is located at Brandon, a city situated just north of the Turtle Mountain region of this State.

Supt. Angus Mackay of the Assiniboia Experimental Farm says Bromus inermis has given excellent results wherever tried in Canada Northwest. He considers it quite hardy there, although the rainfall is light and their winters are severe. He regards it as well adapted for either meadow or pasture and especially for early pasture. He says that it stands close grazing if the rainfall is sufficient. He reports that cutting it for seed reduces the yield of hay for the following season.

TIMOTHY (Phleum pratense.)

Timothy or Herd's Grass is probably the most widely known and popular cultivated grass in the United States. It does not produce as heavy a yield, even in the more humid regions of North Dakota as it does in many of the states further east and will probably take a second place in this State when the seed of Austrian Brome Grass becomes plentiful and, therefore, cheap.

Timothy has been grown upon the Station grounds and College farm for seven years and has not killed out either when used as pasture or for hay. It is often sown in a mixture with common red or mammoth clover, but it may be sown alone. The rate of sowing is usually from ten to twelve pounds of seed per acre. The seed weighs 45 pounds per bushel. The cost for seed does not exceed forty cents per acre, as a rule. The price of seed upon the market constitutes an important item in seeding land to grass. The yield from fields of timothy sown in a mixture with clover upon the college grounds has averaged, approximately, a ton and a quarter per acre. As a pasture grass, it has not formed a compact sod, but has furnished a medium amount of grazing. It succeeds with a nurse crop, particularly with wheat. The greatest degree of success has been obtained at this Station when the seed was put in with a drill in the manner described in the discussion under red clover. The drill has given best results when run very shallow.

RED TOP (Agrostis vulgaris.)

Red top is not generally as successful as timothy in this State except upon low moist soils. Lands which are wet and those which overflow at times will usually produce a good crop of this grass. Like timothy, the seed is usually cheap, which keeps the first cost for seeding from being burdensome. The seed is light and chaffy, weighing fourteen pounds to the bushel. Full seeding of red top requires about twenty-four pounds of seed per acre. It is too chaffy to seed with a drill and is best sown by hand, without a nurse crop. Land which will grow red top successfully, will generally be found to be too wet for a grain crop to be seeded upon it at the season when grain should be put into the soil.

ORCHARD GRASS. (Dactylis glomerata.).

Orchard grass or cock's foot is another of the more popular of the list of grasses grown in the Eastern and Middle states. It has the habit of growing in tufts and bunches and never forms a compact sod. When it is used as a field grass, it is sown with a mixture of other grasses. In trials made at this Station, the results obtained from it indicate that it will not equal timothy or red top as a hay or pasture grass in this climate.

NATIVE PRAIRIE GRASSES.

A large number of prairie or native grasses have been given a trial upon our grounds during the past two years. Seed gathered from the prairies of the west constituted a large proportion of a list of 78 forage plants obtained from the United States Deparement of Agriculture. Seed collected from the prairies of Manitoba, by the Manitoba Experimental Station, was also secured and grown in this trial. From this entire number only two, viz., Wild Rye (Elymus Americanus), and Slender Wheat Grass

(Agropyrum tenerum) have given a degree of promise which will warrant the belief that they may prove superior to timothy for this climate. Neither of them have shown as great a degree of promise as Austrian Brome Grass. We expect to sow a larger area of land to them this season and will thus be able to study them in a more extended way. These two kinds have given good yields of hay at the Manitoba Experimental Farm, as a result of a number of trials.

COMMON RED CLOVER. (Trifolium pratense.)

Common red clover has been sown on the Station grounds or fields each year since 1893. In most cases it has been sown in fields mixed with timothy. It succeeded reasonably well until the winter of 1897-98. when almost all of the old plants winter killed. Two practices differing from those usually followed have been adopted with this crop. The first is in seeding it with a grain drill by running the drill across the rows of wheat, and as shallow as it will run. Bulk enough, to make the rate of seeding right, was obtained by mixing common barrel salt with the seed at the rate of four pounds of salt per acre. Later, ground barley was used to obtain bulk and the wind was prevented from blowing the seed away by setting up a canvas windbreak, about eight inches high, behind the force feed of the drill. The second plan, which differs from that usually followed, is to allow the second growth of clover to stand and hold the snow over the crop, which second growth also adds seed to the land. It was hoped that in this way the crop might be preserved and perpetuated. The yield of hay has been from one to two tons per acre, forming a very fair crop as a rule. In 1898 young clover was seen starting in the old fields, but it will not be sufficiently advanced until 1899 to determine how fully it will regain its hold upon the land. Small trial plots sown to clover have been destroyed or damaged by accidental and unexpected happenings in almost every case. A plot seeded to red clover in 1898 made a good stand and went into winter quarters looking well.

MAMMOTH CLOVER. (Trifolium medium.)

Mammoth clover was sown upon a twenty-acre field with a grain drill in 1895. A small quantity of timothy seed was mixed with it and sufficient barrel salt was added to make the bulk right. Wheat was used as a nurse crop. The land was very rich and produced a heavy growth of clover, the yield of hay being two and a quarter tons in 1896 and two and a half tons in 1897. The winter of 1897-'98 destroyed the plants. There is no second growth of Mammoth clover which makes it impossible for that plant to hold snow or to seed the ground for the production of new plants when it is cut for hay.

ALSYKE CLOVER (Trifolium hybridum.)

Alsyke clover has been grown in trial plots where it has made a poorer showing than either the mammoth or common red varieties. The trials were not extended and were badly interfered with, so that little has been learned from them thus far. Alsyke clover is said to succeed well upon comparatively low, moist land.

ALFALFA (Medicago sativa.)

Alfalfa has been grown at this Station in small trial plots for several years. It has never made a good stand, yet it has not fully killed out at any time. It stood the winter of 1897-'98 better than the clover. When compared with other fodder plants it gives no promise of having special value for this district.

CRIMSON CLOVER (Trifolium incarnatum.)

Crimson clover is an annual plant, i. e., lives but one year like wheat and oats. It is valued in the eastern states for hay production and for growing in orchards. The results of two years trial at this Station indicate that it has no value for the conditions prevailing in this State.

GERMAN MAMMOTH CLOVER.

This is an annual clover almost identified with crimson clover. It was grown upon our trial plots in 1898 and proved about equal to crimson clover.

MELLILOT OR SWEET CLOVER (Mililotus alba.)

This plant has been given some notice in this State as a forage plant from the clover family, which will survive in our climate. In the older states it is usually named as one of the weed pests and in trials made with it upon our grounds it has shown the characteristics which they have described for it as a weed. Stock do not relish it either green or dry. It is a spreading, persistent plant which would probably become troublesome here as elsewhere if allowed to grow.

FIELD PEAS.

White Canadian field peas were grown as a field crop in 1898 and cut for seed. They yielded twenty bushels per acre. Two other varieties were tested on a small scale in the plant nursery. The peas were planted April 17th in rows 16 inches apart and were cultivated.

The Yellow Canadian field peas made a rank growth. The vines reached a length of four to six feet and were loaded with pods. The growth made indicates that they are a promising variety. Blackeyed Marrowfat was the other variety grown. As tested in small plots under the conditions noted above, they made a slightly better showing both for hay and grain than the Yellow Canadian field variety. The Marrowfats have coarser stems and larger pods than the Yellow Canadian field variety. The peas are also larger and more plump. They may be readily distinguished by their black eyes.

If cut when the grain is in the milk, peas make an excellent hay, approaching clover hay in quality. The crop can be grown very successfully, especially upon light soils. The grain is very rich in protein or muscle forming material and gives results similar to oil meal, although less pronounced, when fed to stock. The pea plant, like clover, adds nitrogen to the soil causing it to produce a better crop of wheat

HAIRY OR SAND VETCH, (Vicia villosa.)

Samples of the seed of this fodder plant were received from the United States Department of Agriculture in 1897 and 1898.

In 1897 a small plot was sown, but owing to the heavy rainfall that season, the crop made a very poor growth. In 1898, a small plot was sown on April 17th and another on May 5th. The seed was sown in drills sixteen inches apart and the crop was cultivated. The plants made a good growth completely covering the ground, the vines attained a length of two to four feet. This plant makes a finer and more leafy fodder than do peas. Results from vetch in other years have been much less satisfactory. Our results indicate that it is a forage plant worthy of further trial.

COW PEAS.

A sample of cow peas was planted in 1898. The seed germinated poorly and the plants made a feeble growth. Cow peas are bean-like plants and are not hardy enough to prove valuable in this State.

RAPE.

A small field of rape has been grown on the Station Farm each year. In 1898 two varieties were grown, a small plot, one-twentieth of an acre of each kind having been sown June 25th. On October 8th a row from each plot was harvested and weighed green and the yield calculated. The crop was damaged, some, by plant lice. Dwarf Essex rape yielded 5.66 tons per acre. Dwarf Victoria rape yielded 6.25 tons per acre. Yields of rape as high as thirteen tons per acre have been obtained in previous years. These yields are for a single growth and represent about one-half what the crop would yield if cut off and fed three times during the season, or when pastured by stock. The special value of rape is for use as a green fodder for sheep. Sheep are very fond of it and fatten rapidly upon it. Hogs also do well upon rape for about one-half of their ration, the other portion consisting of grain. Cattle also like it, and trials made at the Ontario Agricultural College indicate that the milk is not tainted by feeding it. It is generally cut off and fed green to stock, or pastured off. A common practice is to divide the field by means of movable hurdles, so as to allow the flock or herd to feed on one part of it at a time until it is fed down, after which, they are given another portion and so on until the crop is fed off. Special care should be exercised when sheep are first placed in a rape field, as they are likely to over eat, causing hoven or bloat. In this way rape is much worse than clover, the effects of which are quite generally known. After they have become accustomed to it, however, as in the case of clover, no injurious effects are noted.

This plant resists drouth well and is a good crop to follow a heavy manuring of land, as it seems to be able to feed on fresh manure quite successfully. It can be sown as late as the first of July and may thus be used as a crop when some other crop has failed. It can be sown broadcast at the rate of five pounds of seed per acre, or it may be sown in drills 30 inches apart at the rate of three pounds of seed per acre and cultivated until the leaves meet across the rows. The latter method is usually the more satisfactory of the two. Wheat following crops of rape, in trials at this Station, which cover a period of three years, 1895 to 1897 inclusive, have given an average yield of 24.9 bushels per acre against 14 bushels per acre for adjoining plots of land which have had no change from wheat, or only a change to rye. Other trials show no benefit to wheat crops from the land having been changed to rye. It seems to have an effect similar to that of wheat upon the crop which follows.

SPURRY.

A small trial plot of spurry (a forage plant for pasture and hay) was planted in 1898. It succeeded better than it has usually done during trials conducted in a sumilar manner in three previous seasons. It does not, however, show a value which will enable it to compete with a number of other forage plants in this State.

J. H. SHEPPERD.

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The last Bulletin issued by this Station will contain a complete index for the entire volume.

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FOR

NORTH DAKOTA.

Bulletin No. 41.

SOME HINTS ON ORNAMENTAL PLANTING.

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Fargo, North Dakota, U. S. A
September, 1899.

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Some Hints on Ornamental Planting.

The work of the pioneer is not towards the ornamental. He is face to face with practical conditions that must be met or he will be forced to leave the country. Only those things bearing directly upon the problem of existence receive attention. Man must first get a living before he builds a home, and ornamental planting has to do with this latter thing. Other things being equal, we measure the civilization of a people by the homes they build. In this comparison we mean the homes of the common people. Lack of means may prevent a man from putting much money into his home, but it is a lack of something else that leaves his home barren and ugly. On the other hand, lavish expenditure does not always make a place comfortable and tasty. A house and its surroundings constitute a natural picture. It is as easy to make poor pictures with natural objects as by other means.

The home is more than an indication of refinement and civilization; it is also a cause of these. Its influence may not be taken account of by busy men and women, and for that reason it is hard for us to appreciate its effect upon children. But there is also a material side to the subject of home ornamentation if such an argument is needed. Ours is and always will be an agricultural state. Her citizens are farmers. Such standing as our state ever merits for her material progress, or for the intelligence and enlightenment of her citizens, will be because of the qualities of her rural classes. So this and the education and surroundings of the younger generation should be of such a nature as to develop them the most and at the same time furnish such attractions as will keep the brightest and most active boys at home. Except as the best brains are applied to the only thing by which our state can ever hope to attain any distinction we must take not only a humble but an ignoble place, and nature's great gift, our fertile soil, cannot permanently alter this fact, though it may hide it for a time.

It is probably not necessary to insist upon these things, but merely to point them out. We know that country homes adorned and made interesting with flowers, trees and shrubs will do much in the right direction toward the training of those in whose hands all affairs will soon be left, and that by such means our best talent is retained in the place where it will do us the most good. This is a plain proposition that should appeal to our good sense and our patriotism, even if we think we can get along pretty well without shrubs and flowers and green lawns. We prove the truth of it every time we drive by an attractive, fresh and shady place, and say to ourselves, "What a nice place that would be to live in!"

I belong to a horticultural society of 700 members and attend their meetings every year. A prominent part of their work in connection with the society is ornamental gardening. These men are for the most part practical farmers. I have often observed that it would be difficult to find in the whole state they represent another body of men of equal number so bright, thrifty, clean and enterprising. They would dignify any assemblage. They are not only the bone and sinew, but the worth and brains of their commonwealth. I state the fact and offer no explanation. There must be some connection between men of such character and the things that occupy their attention.

There is another feature in connection with this society of interest to us, and that is the state in which its members reside. Living in Minnesota they are governed by practically the same conditions of climate that are found with us, and whatever they have accomplished so successfully in horticultural matters, we may hope to achieve in fair measure.

There are many things that are best learned in the doing of them, and of such is ornamental planting or gardening. At the same time there are certain rules and suggestions that must be followed to get good results. They simply represent the experience and observation of others. This bulletin will give some of the more prominent of those both as regards arrangement and materials.

The one thing lacking with us is trees. Trees are naturally associated with what is beautiful and artistic in natural landscape. They also carry with them the idea of strength, of dignity and protection. They give an expression of permanence and stability to a home without which other adornment seems trivial.

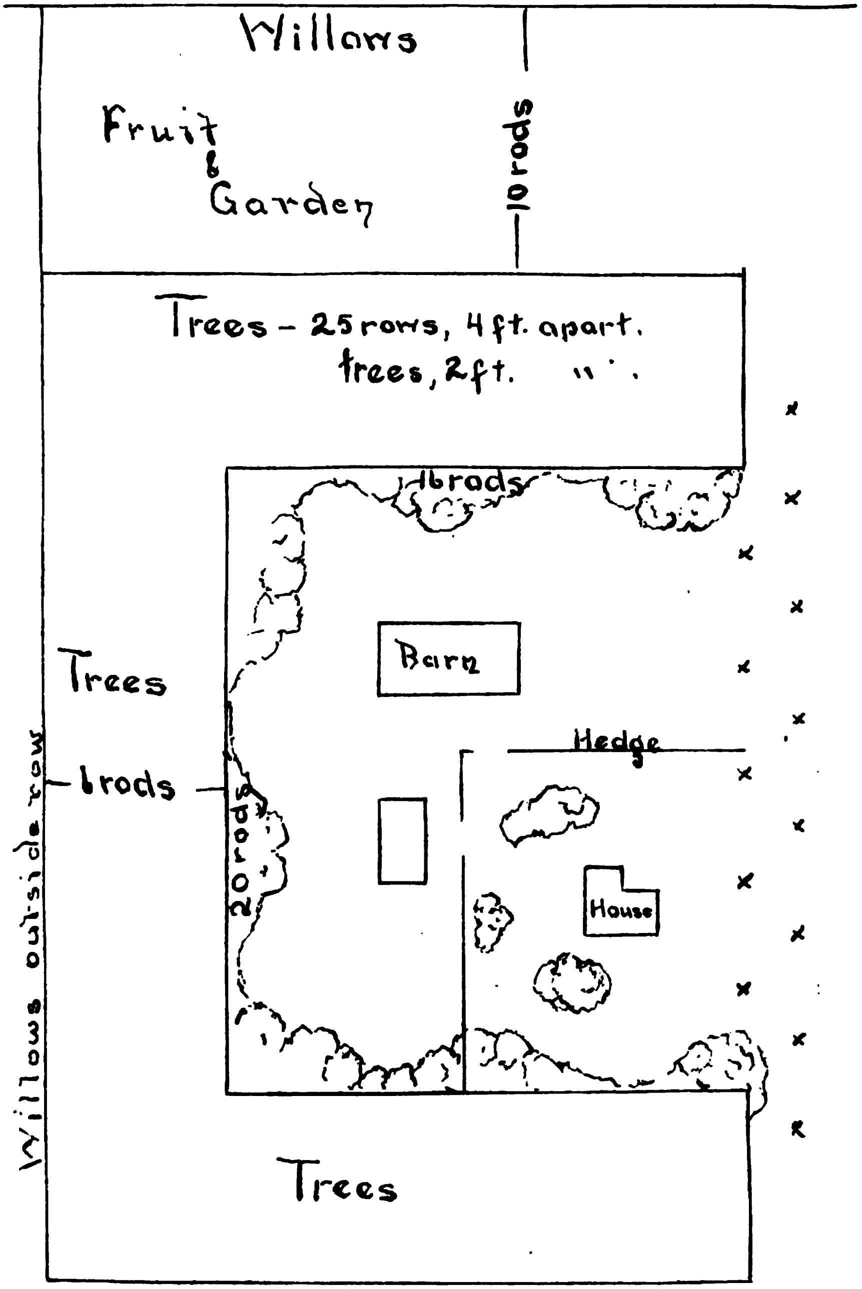
The tree is the pioneer in landscape adornment in prairie states. Where it is established its weaker brethren may come, encouraged by its sturdy protection.

But at first the tree itself needs special care and proper treatment. The small number and poor character of tree plantations in the state indicates that we have much to learn in tree culture. Nature will give us valuable instruction if we but observe her methods. A bit of good, natural timber such as we may find along streams or in broken country presents the following conditions:

First: It is purely woodland. But little else than trees and shrubs and vines are found there. A few shade loving plants may be scattered about, but greedy weeds and unyielding sward are absent.

Second: The soil is characterized by what is termed "forest conditions." It is friable and yielding, full of vegetable matter and retains moisture.

Third: Certain sorts of trees predominate. There are trees, like the cottonwood, that do not thrive when planted thickly. They require



Skeleton plan for planting about farm premises much light and to obtain it must be grown singly or else they will become spindling with weak, open tops and dead lower branches. Other trees grow best in partial shade. They need society of their own kind and, being denied it, perish. They were never meant for the skirmish line, but make up the rank and file.

We will now make practical application of these hints furnished by nature:

First: Subdue the land. Make way with all grass and weeds, especially the grass and particularly the weeds. If your land is in a fair state of cultivation this can be done while the trees are growing. If not, grow a hoed crop for a season and keep it clean. You will naturally want your trees in the region of the buildings. Plant them on the north and west and also the south side if possible. The enclosure should be large enough to give spacious yards, and also to prevent the snow from drifting near the buildings.

The subject of snow is a serious one in connection with tree planting, and the destruction wrought by it has quite discouraged some who had beautiful and thrifty groves. This is because their trees were not arranged properly. In years of very heavy snows of course some damage will be done, but if a single row of willows be planted parallel with the north side of the grove and about ten rods from it, the drift will lie between the willows and the grove and the trees escape serious injury. The trees at this station are protected in that manner and in the winter of '95 and '96 our only injury was to some low, bushy plum trees, while other groves were nearly destroyed. The intervening space when trees are planted in this way may be utilized for small fruits and general gardening. For these operations it is very desirable to have protection from the south winds in summer and a good covering of snow in the winter.

The belt of trees itself should be of good width, if we are to get the conditions found in the forest. The minimum width should be four rods, while a strip twice as wide is better. Around the outside of this belt another row of willows should be planted. The white willow is generally used and found satisfactory, but with us the Golden Russian willow grows faster and is more ornamental. The laurel leaved willow is scarcely inferior to this and has a beautiful foliage. Within the tree-belt come the permanent trees, such as are to give lasting charm and protection to your abode and your children's.

If the trees that you plant are small seedlings of two or three years they must be put close together. Two feet apart in rows four feet apart is about right. If larger trees are used still retain the distance of two feet in the row, but plant the rows eight feet apart. This is the plan employed in Russia where the government, on lands much like ours, has timber belts miles in length covering thousands of acres. The distance between the rows makes cultivation easier, while the trees being close in the row have the needed protection and are made to grow tall.

When the rows are planted but four feet apart every other row will need to be taken up at the end of six or eight years. If the tree plantation is not too large and the trees taken up can be utilized at home or sold, this is the best arrangement. These alternate rows that are to be removed should be of sorts that grow quickly when young and yet are not too rank and greedy for the adjoining trees. This, of course, excludes the cottonwood, which, by the way, is only suited for single specimens, or at best a single line of trees.

My first choice for this purpose would be the box elder, with the white soft maple a close second, where the soil is not too dry. I know it is rare to find a good box elder grove, but that is because the trees were set too far apart and made to fight with grass, a task they are poorly suited for. Whatever drawbacks the box elder has are not of such a nature as to lessen its value for the purpose named. When given too much light it soon becomes thick and bushy in the top and makes but a poor growth after the first fifteen years or so. This fault must be remedied by very severe inside pruning of the top each year or else by growing it in the shade among other trees.

Alternating with these rows are to be set the sorts that grow slowly at the first perhaps, but eventually develop into large and permanent trees. For this purpose we have hitherto recommended the white ash for first place, but with the very general destruction of that species within the year, by a species of bark beetle (*Scolytidae sp*) our good opinions have undergone a change. The few specimens of green ash upon our grounds have not suffered from this cause yet, but the green ash doesn't grow large enough with us to make much of a tree.

The American or white elm is undoubtedly entitled to first rank for this purpose. While attempts to grow it have frequently or generally resulted in failure, this is not an argument against it, but a condemnation of the methods pursued.

Wherever timber is found within the state, along streams or among the hills, the elm is usually the largest and best of the trees. It must be grown thickly and shaded at the sides to get good results. At first the intervening rows of boxelder will outgrow the elm, but after a dozen years the case is reversed and the elm makes rapid growth. The nurse trees should not be allowed to grow out over the elms, but simply furnish shade at the sides. This same rule holds good for all deciduous trees of like character. By this method the lower limbs soon die away; the tree develops a tall, straight stem and the principal growth is upward. To hasten this process the lower limbs may be cut away on specimens tending to be bushy, as is often the case with the elm and soft maple. After six or eight years the elms will crowd each other in the row and alternate ones should be removed, leaving them four feet apart. The nurse trees will also be taken out about the same time, leaving the interior of the belt of permanent trees four by eight feet apart.

On dry soils this rate of thinning will be found too rapid, and only alternate trees of the nurse row should be removed. This will leave the trees four feet apart, in rows the same distance apart, but to give more room the trees should alternate across in this manner:

B B B B B B B B B B
E E E E E E E E E E
B B B B B B B B B B

B representing the nurse aree of box elder or soft maple and E the permanent tree of elm and some of the kinds that will be mentioned later.

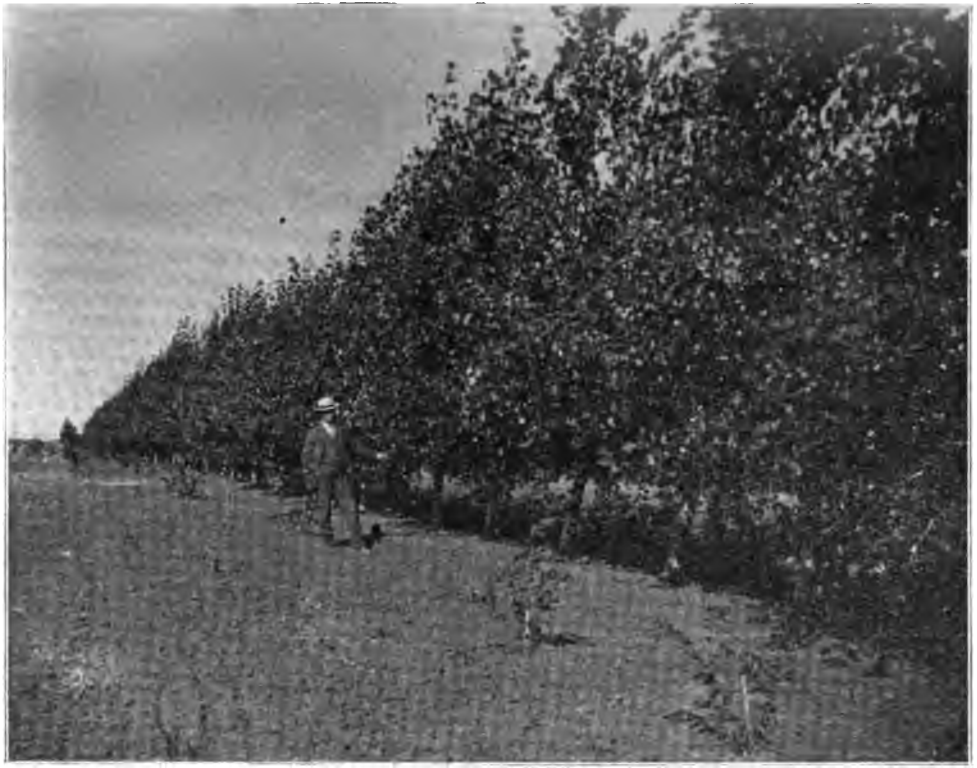
About the only other tree of the state that attains timber size is the bur oak (Quercus Macrocarpa). Specimens three feet in diameter may be found along the Red River. It does not appear to do as well as the elm in the drier parts of the state. On account of its slow growth it is not so well adapted for general planting as the elm. Its vigor and sturdiness make it a very attractive tree and on account of its deep rooting habit it endures tramping of the soil better than other trees. It is difficult to transplant except when very young and is usually grown in place from seed and not transplanted. It should be grown to some extent in every grove. Its growth is steady and uniform, and about nine inches a year. As the oak will usually not be removed for transplanting purposes, a row of oaks should not be grown nearer than twenty-four feet to another row of the same kind. If seedlings are used the same distance may be maintained to advantage in both directions, taking care not to let the neighboring trees overtop them.

Other trees useful for permanent planting and requiring about the same treatment and conditions are the hackberry, basswood, and rock elm. These may be mixed with the elms where they will give variety. The hackberry is a very trim and graceful tree and is usually grown for ornamental effect. It is a native of the state and one of our best trees.

As we reach the opposite side of our timber belt, smaller and more graceful trees with rich, heavy foliage should be used to give the proper ornamental effect.

The grove should not break off grim and harsh, exposing the bare trunks of the trees, but should blend itself into the landscape through the easy stages of birch and choke-cherry, with still smaller shrubs like the yellow current and juneberry at the last. These give a much better effect upon the inner margin if not confined to straight rows. A protecting mass of wild-plum trees here and receding stretches of red ozier or sumac there, give variety and artistic effect.

It must not be supposed that because these shrubs growing wild and



WIND BREAK OF COTTONWOODS; SIX YEARS OLD FROM SEED.

trampled upon by stock are ragged and unsightly that they do not readily grow into good form when protected. In any city park you will find the despised native shrubs of your woodlands growing in such elegance and grace that you hardly recognize them, simply from the good care they get. Thereby hangs a moral, but just now we will apply it only to plants. Of course, one may add variety by introducing suitable trees and shrubs, and a list of such is added to this bulletin.

The important thing, however, is in the arrangement. On page 473 will be found a general outline, such as, by the proper changes, could be adapted to almost any place. Beginning at the outside of the yard or the inside boundary of the trees, the planting for ornamental effect begins. A hint as to how this part of the grounds should be treated has already been given.

We are through planting in rows, that was done within the tree-belt simply for convenience in cultivating. The object now is to plant so as to change the stiff, straight lines into flowing and irregular forms, such as give natural landscape its charm and make certain parks and places famous. To get this effect you must plant thickly and not mix the different sorts too much. At any particular place let some one sort predominate, adding a few of one or two other kinds to give variety. At the outside of the place the larger and coarser shrubs should be used. The wild plum, choke-cherry and white thorn are suitable here.

So far all of the planting has been in connection with the timber strip. Removed from this and near the house at the sides or rear should be planted two or three clumps with a somewhat irregular circular or oblong outline. The clump may be anywhere from ten to forty feet across, depending upon the materials to be used. Clumps of the smaller size should be made up of shrubs while the larger ones may have trees at the center, the plants becoming smaller as the outside is reached. Now comes an opportunity for the plants recognized as strictly ornamental, like the lilac, snowball, Tartarian honeysuckle, spireas, barberry, red cornus, caragana, etc. There are many others of great beauty and perfect hardiness that one would naturally obtain from time to time, as he became interested in his place and its development.

We have the same reasons for grouping shrubs upon the lawn that we have for planting trees close together. They look better, grow better and are more easily tended. It spoils the appearance of a lawn and makes it look smaller to have bushes planted singly and indiscriminately here and there. Aside from that, unless heavily watered, they make but a poor, scraggy growth that is anything but ornamental. Planted in groups the soil may be kept cultivated between the plants and a good growth secured. After the first few years the ground will be shaded and will not need cultivation. Among the shrubs, and especially about the margins of the groups, smaller plants may be grown with the best possible effect. These may include plants grown for their foliage, like the corleus, geraniums, cannas, or euphorbias, or for the effect of their flowers, like the asters, zinnias iris, nasturtiums, narcissus, tulips, or whatever the fancy demands. It is not necessary to have a great variety so long as they are tastefully and properly arranged. With flowers as with shrubs, a better effect is secured by planting a number of one kind near each other than by mixing indiscriminately. It is hardly desirable upon the ordinary place to have special beds for flowers. The effect is far better when one runs across them here and there along the borders and among the shrubbery.

The most attractive private place I ever visited, one in which thirty gardeners are employed, has a great profusion of flowers, but not one flower bed. You run across them constantly in walking about the grounds, just around the bend of the walk, or half hidden by the foliage, where they form a succession of happy surprises.

In massing the material used for decorative purposes one not only secures the advantages already named, but also that of broad, open stretches of lawn that are easily tended and make the place appear larger, especially if they are bounded by masses of foliage that blend naturally with the green of the lawn.

FENCES AND HEDGES.

If a boundary is needed on one or more sides, as is usually the case on farm premises, it may consist of a stout hedge or a wire fence covered with vines. Almost any tree or large shrub can be kept trained to hedge form, but some plants are especially adapted for this purpose, as they make a stiff growth and endure pruning well. The buffalo-berry or bull-berry is one of the best of these, while the wild plum and the thorn are also very good. To get a hedge started quickly a strip of land four feet wide on each side must be kept clean and well cultivated for four or five years. After this time the strip should be sown to white clover, as that retards the growth of the hedge less than grass and at the same time is an effectual barrier against weeds that like to steal a secluded place close to the hedge. It is found that hedge plants set eighteen inches or two feet apart make a more even and thrifty hedge than when set closer. The plants are set in the spring and well cultivated until fall. After the plants become dormant they are cut back close to the ground. The growth the second season will consist of three or four vigorous shoots that are allowed to attain their full height. Before the growth begins next season these are cut back to about a foot in length. After the third season prune back to about two feet. All of this is very essential if we would get a thick, bushy and effective hedge that is alive and green clear to the bottom. After this the hedge may be kept at any required height, but considerable attention must be given to its form if we would keep it green and healthy all over.

If the top is made too broad or allowed to become very thick, the lower and inner branches die through the effect of over-shading. To prevent this the broadest part of the hedge should be toward the bottom and enough pruning done in the interior of the plants to let some light in, making the hedge green to the center. Much more might be said about the care of hedges, but these simple suggestions, easily followed, will insure good results. For purely ornamental purposes the common lilac, barberry, buckthorn, or yellow flowering currant all make attractive and enduring hedges.

A common wire fence with wood-bine planted at the posts and trained along the wires, makes one of the prettiest of boundary fences. In Germany the American wood-bine or Virginia creeper is considered the best of all climbers, and is used extensively for the purpose named excepting there chain fences are made, along which the wood-bine grows, making rich and graceful festoons. The wild grape and shrubby bitter sweet are both good climbers, and like the wood-bine, perfectly hardy. The further use of these vines, in producing ornament and protection to the house, need hardly be mentioned. Large trees with bare trunks and limbs growing near the house make it look cheerless, while vines and shrubs have the opposite effect. No landscape architect of the present day would consider a place complete without these living ornaments to the house. At one or more corners of the house, and often clear across, should be a trim compact bank of shrubs with vines growing above them onto the house and over the porches. Shrubs for this purpose should be of the finer sort, like the Persian lilac, purple barberry, spireas and hardy roses, of which the yellow Scotch rose and the *Rosa rugosa* are the hardiest.

SOME PRACTICAL POINTS.

It is not necessary nor in many cases advisable to attempt to accomplish in one season even the things outlined in this bulletin. Plant but one side of your timber belt and get that well started. It won't require quite as much care the second season if well tended the first, while on the other hand a lot of the trees only indifferently cultivated the first season will be but little more than alive in the fall and a second season of neglect will finish them. Start right by planting a reasonable number of trees in deep, moist soil and keep the soil moist through cultivation. That one word is the secret of all success in tree culture. The cuts that you see in this bulletin of ash trees six years are of trees that were never irrigated, but cultivated every two weeks throughout the growing season. This operation is necessary till the ground becomes well shaded which will be from eight to ten years. If single specimens are grown these also must be kept cultivated, not only to the extent of keeping the grass and weeds down for a distance of three feet from the tree, but the soil should be raked loose every few days. If you would know the reason for this, determine by accurate means the amount of moisture in cultivated as compared with that in uncultivated spaces.

There is some satisfaction in undertaking an enterprise that gives increased results as time goes on. While care is required at first, the time soon comes when without attention, even while you sleep, the spot where you are to spend your days and end them is constantly growing into perfection such as only flowers and trees attend. The man in his prime looks lightly upon these things, but age regards with a special pride the strong and beautious trees that his hand set, knowing that his timely and thoughtful act will long endure in the cool shade and grateful protection that the groves afford.

C. B. WALDRON.

The following paper was read at the last meeting of the Minnesota Horticultural Society by Frank H. Nutter, park engineer for the City of Minneapolis. It is printed here on account of the good suggestions it contains from one whose work is sufficient recommendation.

LOCATING SHRUBS FOR EFFECT.

Many and indeed most of those who enter with enthusiasm on the improvement of their home grounds, devote both time and money to the securing of trees for this purpose, and frequently too many of them; and then, deeming their task complete, "retire upon their laurels." When, however, the trees begin to shoot upward, and, shedding their lower branches, open up the grounds again to the searching winds, it is seen that without the co-operation of their more humble allies, the shrubs and dwarf trees, their mission is but poorly accomplished.

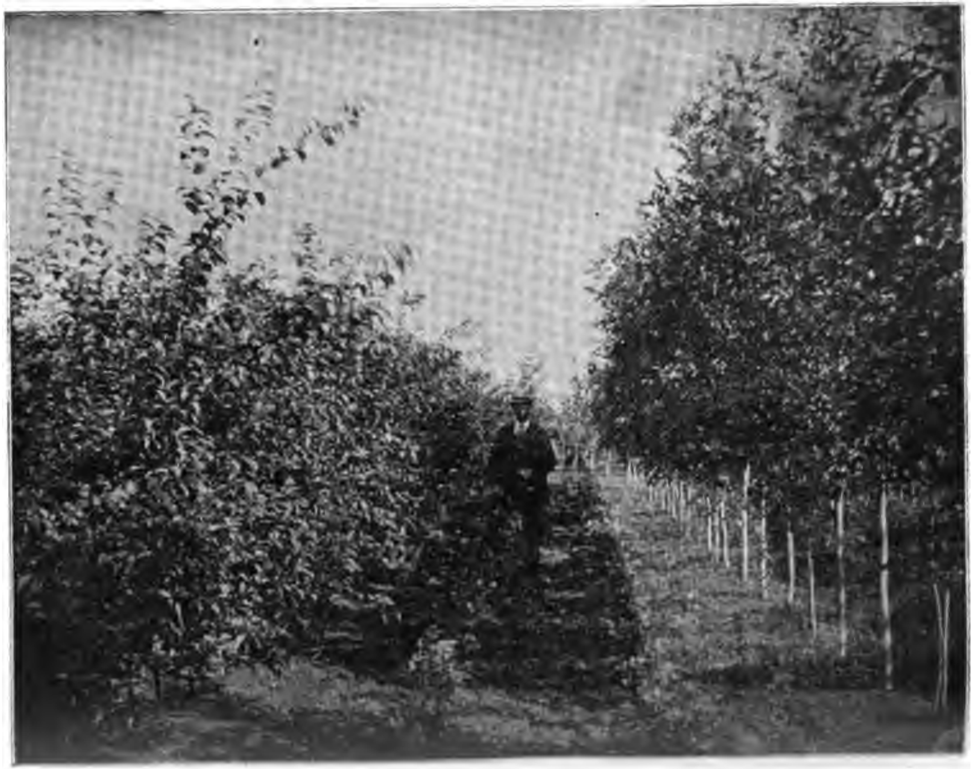
Much more effective, even as a shelter-belt, will a group of trees become if its borders be extended somewhat by dwarf willows, dogwoods, thorns, etc., from the neighboring swamps and thickets.

From the standpoint of scenic effect also these minor additions are of value, for however attractive the interior of an open grove may be, it becomes more so when it is screened and partially concealed by well disposed groups of shrubs.

To the owner of grounds of limited extent, the shrubs come with particular value. Very few trees perhaps can be accommodated on the narrow lawn, and often they will have to be relegated to the sidewalk row; one or two smaller and select varieties of tree, as the Wier's maple, cut-leaf birch, or weeping mountain ash, or some dwarf evergreen, may be placed upon the lawn, but the principal dependance must be placed upon the shrubs, and gallantly will they come to the aid of those who put their trust in them.

How, then, shall they be arranged to give the best effects?

The Father of American Landscape Gardening, in his desire to



WHITE ASH IN GROVE; FIVE YEARS OLD FROM SEED.

combat the ideas of geometrical planting prevailing in his time, suggested that better results might be obtained if the planter would take the necessary number of potatoes, and, throwing them at random in the air, set his trees wherever the tubers might be found resting on the lawn. Sometimes we find shrubs dotted all over the grounds in such a way as to indicate that the owner had literally followed some such advice; but as we contemplate the spottedness that results and the lack of open lawn space, we feel that the spirit of the great artist, if present, would add to his former suggestion, a clause to the effect that, when applied to shrubberies, the garden rake should first be called into use, to draw the potatoes into more intimate relationship with each other, and to afford those broad spaces of sunlight so essential to a perfect picture.

It is evident then that under ordinary circumstances our shrubberies should be arranged around the boundaries of our lawns, but other considerations may also influence the special location of them. Many necessary details of domestic economy, especially in the country, are not always desirable features in the landscape, and whether far or near, properly arranged plantations may entirely screen them, or with the addition of vines, so drape the obnoxious object as to change it into a thing of beauty.

The individual taste of the owner will also point to specific effects desirable in these plantings.

If he desires the brightest reminders of opening spring, many early-blooming species will serve him, and on through the calendar of flowers he will find those varieties which will continue the feast of colors until autumn frosts replace the blasted blossoms with the richer scarlets and yellow of the dying leaves.

Even in winter their beauty will not flee, for the many-tinted fruits and seeds of the cranberry bush, the bittersweet, the wild rose and the winterberry, the crimson wands of the dogwood, the golden bark of the willow and the evergreen of the spruce and pine stand out the more vividly for their drapery of sparkling frost or fleecy snow.

In obtaining all or any portion of this, some rules, however, may be followed to advantage.

While an occasional fine or rare specimen may stand somewhat apart on the lawn, it is well to keep most of the plantings more compact, though, of course, with irregular outlines of bed.

In these plantings the different species or kindred species should be massed rather than scattered promiscuously throughout the borders; the latter arrangement would give a spotted effect throughout the season, but massed as suggested, first one section of the shrubberies and then another will burst into bloom as the season rolls by.

Vividly colored foliage of golden, red or purple, and fantastically variegated shrubs will appeal forcibly to some planters, and while, if used cautiously, the effects may be pleasant, they must be used with caution and the main reliance placed upon the old standard varieties which have proved reliable in our climate. The same may be said as to many of the novelties so much lauded in print at so much per line.

It should be borne in mind that some varieties of strong growing, hardy perennials, as the asclepias, dicentra, coreopsis, day, wood or tiger lilies, helianthus, rudbeckia, goldenrods, peonies, etc., may be interspersed with the shrubs or planted on the borders of the group to great advantage, and the effects of the bright flowers obtained at times when flowering shrubs are rare.

In places where half-wild thickets are desired, the wild grape, woodbine or native clematis clambering over the tops of the shrubs will add to their effect.

In strictly ornamental plantings, where, on the finished lawn, beds of foliage plants are suggested, the undesirable intrusion on the more valuable open lawn may be avoided by planting the cannas, caladiums, and other exotics in connection with the shrubbery borders.

But, wherever used, whether as specimen plantings on the lawn, around the borders of the grounds to conceal or enhance the distant view, or around the foundations of the house and other buildings to blend them more perfectly with their surroundings, we will find that our shrubs will richly repay our labor, and like many of the humble things of life, to be not only useful, but absolutely necessary to the satisfactory completion of anv scheme of improvement.

TABLE OF HARDINESS.

From Minnesota Bulletin No. 24.

DECIDUOUS TREES.

Common Name.	Botanical Name	Minnesota Experiment Station Notes.	Wyman Elliott, Minneapolis.	L. R. Moyer Montevideo, Chippewa Co.	N. D. Experiment Station Notes.	J. S. Harris, La Cresent, Minn.	E. H. S. Dartt Owatonna, Minn.
White or Soft Maple	Acer dasycarpum	Hardy	Hardy	Hardy	hardy	hardy	I like it
Cut Leafed Maple	Acer " var. Wierii	Very Hardy	Hardy	Hardy		hardy	doubtful
European Birch	Betula alba	Hardy	Hardy	Hardy	hardy	hardy	fair
Cut Leafed Birch	Betula Alba, var, laciniata	Hardy	Hardy		hardy	hardy	fair
Purple Birch	Betula alba, var, atropurpurea	Hardy	Hardy		hardy	hardy	seems hardy
Canoe or Paper Birch	Betula papyracea	Hardy	Hardy		hardy	hardy	
Yellow Birch	Betula lutea	Hardy	Hardy	Hardy	hardy	hardy	
American White Birch	Betula populifolia	Hardy	Hardy		hardy		
American Hornbeam	Carpinus Americana	Hardy	Hardy		hardy	hardy	
Hackberry or Nettle Tree	Celtis occidentalis	Hardy	Hardy	one of our best lawn trees	hardy	one of our best trees	
Cockspur Thorn or Thorn Apple	Crataegus crusgalli	Hardy	Hardy		hardy	hardy	
White Ash	Fraxinus Americana	Hardy	Hardy	not hardy	hardy	hardy	hardy
Green Ash	Fraxinus viridis	Hardy	Hardy	hardy	hardy	hardy	
Kentucky Coffee Tree	Gymnocladus Canadensis	Hardy	Hardy	hardy		Hardy	all right
Butternut	Juglans cinera	Hardy	Hardy in heavy soil	hardy		hardy	first rate
European Larch	Larix Europea	Hardy	Hardy	short lived	hardy	hardy	hardy
Tamarack	Larix Americana	Hardy	Hardy	short lived	hardy	hardy	inferior
Box Elder	Negundo aceroides	Hardy	Hardy	hardy	generally hard	hardy	hardy but not desirable

Ironwood	Ostrya Virginica	hardy	hardy	does well under cultivation	hardy	hardy	
White or Silver Poplar	Populus alba	hardy	hardy	hardy	hardy	hardy	hardy but a nuisance
Bolleana Poplar	Populus alba, var nivea	hardy	hardy			hardy	hardy
Russian Poplar	Populus Wobsky	hardy		doing well		hardy	
Russian Poplar	Populus certinencis	hardy	hardy	hardy		hardy	
Russian Poplar	Populus Siberica pyramidalis	hardy	hardy	hardy		hardy	
Russian Poplar	Populus betulifolia	hardy	hardy	hardy		hardy	
Russian Poplar	Populus laurifolia	haady	hardy	hardy		hardy	
Cottonwood	Populus monilifera	hardy	hardy	hardy but kills out on dry ridges	hardy	hardy	a poor tree.
Golden Poplar	Populus monilifera, var Van Gerti	hardy				hardy	
Black Cherry	Prunus serotina	hardy	hardy	hardy		hardy	hardy
Choke Cherry	Prunus Virginica	hardy	hardy		very hardy	hardy	hardy
Bird Cherry	Prunus Pennsylvania	hardy	hardy		very hardy	hardy	hardy
European or Mountain Ash	Pyrus aucuparia	very hardy	hardy	liable to sun scald	hardy	hardy	pretty good
Native Crab Apple	Pyrus coronaria	hardy	hardy			hardy	hardy
Weeping, Mountain Ash	Pyrus aucuparia, var. peudula	very hardy	hardy				
American Mountain Ash	Pyrus Americana	very hardy	hardy		hardy	hardy	
Burr Oak	Quercus macrocarpa	hardy	hardy	best tree in West Minn	always hardy	hardy	hardy
White Oak	Quercus alba	hardy	hardy	hardy	always hardy	hardy	hardy
Red Oak	Quercus rubra	hardy	hardy				hardy
Scarlet Oak	Quercus coccinea	hardy	hardy				hardy
Russian Willow	Sali cutifolia	hardy	hardy	doing well		hardy	hardy
Laurel Leafed Willow	Salix laurifolia	hardy	hardy	doing well		hardy	a fine tree
Royal Willow	Salix regalis	doing well					
Russian Golden	Salix aurea	hardy	hardy	doing well	hardy; will not stand drought when growing	hardy	hardy
Napoleon's Willow	Salix Napoleonis	hardy	hardy			hardy	
Wisconsin Weeping Willow	Salix	very hardy	very hardy	succeeds here		doing well	desirable.
White Willow	Salix alba	hardy	hardy	hardy	hardy	hardy	

Spindle Tree	Euonymus atropurpureus	hardy		very hardy		hardy	
Hardy Hydrangea	Hydrangea paniculata grandiflora	hardy	hardy	not hardy		hardy	
St. John's Wort	Hypericum Kalmianum	very hardy					
Tartarian Honeysuckle	Lonicera Tartarica	hardy	hardy	very hardy	hardy	hardy	
Tartarian Honeysuckle	Lonicera Tartarica, var splendens	hardy	hardy	very hardy			
Syringa or Mock Orange	Philadelpheus coronarius	hardy	hardy	very hardy	nearly hardy	hardy	
Syringa or Mock Orange	P. grandiflorus	hardy	hardy	very hardy		hardy	
Syringa or Mock Orange	P. Gordonianus	hardy	hardy			hardy	
Nine Bark	Physocarpus opulifolius	hardy	hardy		hardy	hardy	hardy
Golden Spirea	Physocarpus opulifolius, var aurea	hardy	hardy		hardy	hardy	hardy
Shrub Cinquefoil	Potentilla fruticosa	hardy		does well here in dry soil		hardy	
Common Buckthorn	Rhamnus Catharticus	hardy	hardy	hardy	hardy	hardy	
Common Smooth Leafed Sumach	Rhus glabra	hardy	hardy		hardy		
Cut Leafed Sumach	Rhus glabra, var laciniata	very hardy			hardy		
Yellow Flowering Currant	Ribes aureum	hardy	hardy	hardy	hardy	hardy	hardy
Common Elder	Sambucus canadensis	hardy	hardy		hardy	hardy	hardy
Red Berried Elder	S. racemosa	hardy	hardy	hardy		hardy	hardy
Cut Leafed Elder	S. nigra, var aurea	very hardy	hardy				hardy
Buffalo Berry	Shepherdia argenta	hardy	hardy	hardy	hardy	hardy	
Van Houtte's Spirea	Spirea, Van Houtt	hardy	hardy			hardy	
	Spirea obovata	hardy	hardy				
Douglas' Spirea	Spirea Douglasi	very hardy	hardy			hardy	
	Spirea lanceolata	hardy	hardy			hardy	
Plum Leafed Spirea	Spirea prunifolia	hardy	hardy				
Ash Leafed Spirea	Spirea sorbifolia	hardy	hardy		hardy	hardy	
Aypericum Leafed	Shypericifolia	very hardy		hardy	hardy (?)		
Snowberry	Symphoricarpus	hardy			hardy	hardy	
Common Lilac	Syringa vulgaris	hardy	hardy		hardy	hardy	hardy
Persian Lilac	Syringa Persica	hardy			hardy	hardy	
Josika's Lilac	Syringa Josikaea	hardy			hardy	hardy	
High Bush Cranberry	Viburnum opulus	hardy	hardy		hardy	hardy	hardy
Snowball	V. opulus var sterilis	hardy	hardy		hardy	hardy	hardy
Viburnum	Viburnum lentago	hardy	hardy	hardy		hardy	
Viburnum	Viburnum dentatum	hardy	hardy			hardy	
Prickly Ash	Zanthoxylum Am	hardy	hardy	hardy	hardy	hardy	hardy

DECIDUOUS TREES—CONTINUED.

Common Name	Botanical Name	Minnesota Experiment Station Notes	Wyman Elliott, Minneapolis.	L. R. Moyer Monteviedo, Chipppewa Co.	N. D. Experiment Station Notes.	J. S. Harris La Cresent, Minn.	E. H. S. Dartt Owatonna, Minn.
Basswood or American Linden	Tilia Americana	hardy	hardy	a fine tree	should be protected from wind	hardy	a fine tree
American or White Elm	Ulmus Americana	hardy	hardy		hardy		
Red or Slippery Elm	Ulmus fulva	hardy	hardy	hardy	hardy	hardy	hardy
Weeping Slippery Elm	Ulmus, "var pendula	hardy				hardy	
Rock Elm	Ulmus racemosa	hardy	hardy	hardy	hardy	hardy	a fine tree

ORNAMENTAL SHRUBS.

Common Name.	Botanical Name.	Minnesota Experiment Station Notes.	Wyman Elliott, Minneapolis.	L. R. Moyer, Montevideo Minn.	N. D. Experiment Station Notes.	L. C. Harris La Cresent Minn.	E. H. S. Dartt, Owatanna, Minn.
Common or European Barberry	Berberis vulgaris	hardy	hardy				hardy
Purple Leafed Barberry	Barberis vulgaris var.					hardy	hardy
Thunberg's Barberry	B. Thunbergii	hardy	hardy		hardy	hardy	
Siberian Pea Tree	Caragana arborescens	hardy	hardy	hardy	hardy	hardy	hardy
Red Twigged Dogwood	Cornus, sanguinea	hardy	hardy		hardy and desirable	hardy	hardy
Red Twigged Dogwood	Cornus, stolonifera	hardy	hardy		hardy and desirable	hardy	hardy

ORNAMENTAL VINES.

Common Name.	Botanical Name.	Minnesota Experiment Station Notes	Wyman Elliott, Minneapolis.	L. R. Moyer, Montevideo, Chippewa Co.	N. D. Experiment Station Notes.	J. S. Harris, La Cresent, Minn.	E. H. S. Dartt Owatonna Minn.
American Ivy	Akebia quinata	tender					
Virginia Creeper	Ampelopsis quinq'eflia	hardy	hardy	hardy	hardy and vigorous		
Dutchman's Pipe	Aristolochia sipho	unreliable				fair	
Bitter Sweet	Belastrus scandens	hardy	hardy	very hardy	hardy	hardy	
European Sweet Clematis	Clematis flammula	not hardy					
	Clema., Jackmanni	needs protection	needs protection	does well if protected in winter			
	Clematis coccinea	needs protection					
Virgin's Bower	Clematis Virginiara	hardy	hardy	very hardy	hardy	hardy	
	Clematis viticelli	hardy			hardy (?)	hardy	
Hoheysuckle	Lonicera, Suilivanti	hardy		hardy		hardy	
Moonseeed	Mentispermum canadense	hardy	hardy	very hardy	hardy	hardy	
Wild Grape	Vitis riparia	hardy	hardy	hardy	hardy	hardy	

JUN 8 19

NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 42.

FIELD NOTES OF HORTICULTURAL DEPARTMENT.

Any farmer in the state can have the bulletins of the Station mailed to his address, free of charge, upon application.

Fargo, North Dakota, U. S. A
December, 1899.

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Field Notes of Horticultural Department.

In the spring of 1898 a series of experiments was inaugurated to determine the influence of different classes of fertilizers upon different garden vegetables

The points to be noted were:

First: The influence upon total yield.

Second: The influence upon quality and habit.

Third: The influence upon maturity or time of ripening.

Fourth: The influence of different elements at different stages of the plant's growth.

Fifth: The effect that the different fertilizing elements, applied in the early stages of growth, might have upon the subsequent development of the plant, and

Sixth: The relative value of the different animal manures, applied to the same problems named above.

This work was continued through the seasons of '98 and '99. The report now presented touches only upon points one and three, and the results under these heads are largely negatives.

Under the heads four, five and six we have complete notes of some positive and rather striking results, the publication of which is deferred till they can be confirmed by another season's trial, and also until fuller photographic records can be obtained.

The publication of the present tables will show the relative value of a number of different varieties, but the differences resulting from the different fertilizers, as affecting the total yield, is too varying and uncertain to be of much value without further test.

The work done under heads four, five and six was upon different plots from which the records here given were taken. Upon those plots the differences in most cases are marked and uniform.

In the tables here presented no great increase in yield was expected except in plots one and eight. On comparing the results of these with plot five on which no fertilizer was used it will be seen that in many cases there is no increase, and in no case is it great enough to warrant the application of the fertilizer.

This is the more remarkable considering the fact that the plots used were the ones that had received the same treatment the previous season, and that the land employed had been cultivated about twenty years, and during that time had never been in grass, and had been manured but once

On plot one the complete fertilizer used had the proper proportions of phosphoric acid, potash and nitrogen, while the stable manure on plot eight consisted of well rotted horse manure.

The soil upon which all experiments were made is a rich, black, prairie loam containing about five per cent of humus, seven per cent nitrogen five potash and only a trace of phosphates.

When nitrogen, potash or the phosphates alone were used, the object was to get some clew to what would likely be the most profitable proportions, and not with the idea of getting an increase in all cases.

The most striking part of the experiments is the apparent indifference of the soil to any and all fertilizers.

The great uniformity of the soil in the Red River Valley would render any experiments affecting the total yield of considerable importance, but so far all we can say is that the manner in which the soil is handled has far more to do with the returns than a heavy application of the best fertilzers. The work so far would indicate that the time and depth of plowing, protection of the soil in winter, manner of cultivating, time of seeding, transplanting, etc., are lines offering a better opening for experimentation than the one here recorded.

It will be noticed that with the larger sorts of onions transplanting gives much the best results, and the gain is considerable, even with the ordinary sorts.

The Gibraltar makes a better showing than the Prizetaker, both in size and quality.

The difference in behavior between certain varieties of the same vegetable may be accounted for in some instances, as in beets, on the basis of different habits of growth; in other cases no explanation seems possible.

The publication of the notes under points four, five and six will furnish material having a general value, and not confined alone to the Red River Valley.

The weights in the onion tables are given in ounces, and in the other tables are expressed in grams, of which 28 make nearly an ounce and 454 a pound.

The check plot is number five in all cases, and upon this no fertilizer was applied.

C. B. Waldron.

TABLE I.

BEETS, BRAZILIAN.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING					
			Number Harvested	July 20—Total Weight	Average Weight	Number Harvested	July 25—Total Weight	Average Weight
1	Complete Fertilizer	560	4	200	50	4	170	42
2	Superphosphate	400	4	215	53	3	309	103
3	Kainit	640	4	250	62	3	239	79
4	Nitrate of Soda	160	3	165	55	3	168	56
5	Check		4	250	62	8	109	36
6	Salt	320	5	150	30	3	138	46
7	Lime	8000	4	135	34	2	102	51
8	Stable Manure	80000	3	75	25	2	53	26

TABLE II.

BEETS, WILSON'S IMPROVED BLOOD TURNIP.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING														
			No. Harvested	July 20—Total Weight	Average Weight	No. Harvested	July 22—Total Weight	Average Weight	No. Harvested	July 25—Total Weight	Average Weight	No. Harvested	August 3—Total Weight	Average Weight	No. Harvested	August 16—Total Weight	Average Weight
		LBS.															
1	Complete Fertilizer......	560	11	1450	132	8	1230	154	6	1287		8	2425	303	10	6285	628
2	Superphosphate............	400	11	1795	163	8	1205	151	6	1055		7	1547	221	9	5060	562
3	Kainit	640	13	1540	171	6	1465	244	5	1379		7	2682	383	9	7485	831
4	Nitrate of Soda...	160	11	2030	203	6	1230	205	6	1237		7	1907	272	9	5560	617
5	Check..............................		12	1500	125	8	1025	128	6	1049		9	3250	361	9	5185	576
6	Salt	320	13	1910	138	10	1397	140	8	1425		9	2870	318	13	3890	389
7	Lime...	8000	13	1705	170	7	1140	163	5	687		6	1310	218	10	5520	552
8	Stable Manure.	80000	9	1420	158	6	973	162	5	640	128	6	2050	341	19	5975	314

TABLE III.

BEETS, DETROIT.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING											
			Number Harvested	July 19—Total Weight	Average Weight	Number Harvested	July 22—Total Weight	Average Weight	N Harvested	July 25—Total Weight	Average Weight	Number Harvested	August 15—Total Weight	Average Weight
1	Complete Fertilizer............	Lbs. 560	8	700	87	6	945	157	4	945	236	14	7780	556
2	Superphosphate....................	400	9	705	78	6	1125	187	5	825*	165	15	9935	662
3	Kainit..................................	640	11	2165	196	8	1340	167	6	1192	198	21	9396	447
4	Nitrate of Soda	160	12	1425	119	8	865	106	6	1122	187	21	9500	453
5	Check		11	950	86	8	900	112	7	1035	148	21	9295	443
6	Salt....................................	320	17	930	58	12	950	79	8	922	115	25	11440	453
7	Lime....................................	8000	15	915	61	10	1155	115	9	950	105	25	9790	392
8	Stable Manure	80000	10	790	79	8	970	121	6	1125	187	18	8940	497

TABLE II.

BEETS, WILSON'S IMPROVED BLOOD TURNIP.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING														
			No. Harvested	July 20—Total Weight	Average Weight	No. Harvested	July 22—Total Weight	Average Weight	No. Harvested	July 25—Total Weight	Average Weight	No. Harvested	August 3—Total Weight	Average Weight	No. Harvested	August 16—Total Weight	Average Weight
		LBS.															
1	Complete Fertilizer......	560	11	1450	132	8	1230	154	6	1287		8	2425	303	10	6285	628
2	Superphosphate......................	400	11	1795	163	8	1205	151	6	1055		7	1547	221	9	5060	562
3	Kainit	640	13	1540	171	6	1465	244	5	1379		7	2682	383	9	7485	831
4	Nitrate of Soda...	160	11	2030	203	6	1230	205	6	1237		7	1907	272	9	5560	617
5	Check..................................		12	1500	125	8	1025	128	6	1049		9	3250	361	9	5185	576
6	Salt	320	13	1910	138	10	1397	140	8	1425		9	2870	318	13	3890	399
7	Lime..............................	8000	13	1705	170	7	1140	163	5	687		6	1310	218	10	5520	552
8	Stable Manure.	80000	9	1420	158	6	973	162	5	640	128	6	2050	341	19	5975	314

TABLE III.

BEETS, DETROIT.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING											
			Number Harvested	July 19—Total Weight	Average Weight	Number Harvested	July 22—Total Weight	Average Weight	N Harvested	July 25—Total Weight	Average Weight	Number Harvested	August 15—Total Weight	Average Weight
		LBS.												
1	Complete Fertilizer..........	560	8	700	87	6	945	157	4	945	236	14	7780	556
2	Superphosphate	400	9	705	78	6	1125	187	5	825	165	15	9935	662
3	Kainit..........	640	11	2165	196	8	1340	167	6	1192	198	21	9395	447
4	Nitrate of Soda	160	12	1425	119	8	865	108	6	1122	187	21	9500	453
5	Check		11	950	86	8	900	112	7	1035	148	21	9295	443
6	Salt.......	320	17	980	58	12	950	79	8	922	115	25	11440	453
7	Lime............................. ..	8000	15	915	61	10	1155	115	9	950	105	25	9790	392
8	Stable Manure	80000	10	790	79	8	970	121	6	1125	187	13	8940	497

TABLE IV.

BEETS, EDMONDS.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING														
			No. Harvested	July 20—Total Weight	Average Weight	No. Harvested	July 22—Total Weight	Average Weight	No. Harvested	July 25—Total Weight	Average Weight	No. Harvested	Sept. 20—Total Weight	Average Weight	No. Harvested	Oct. 10—Total Weight	Average Weight
		LBS.															
1	Complete Fertilizer...............	560	9	800	88	7	865	123	5	940	188	14	13608	972	..	....	....
	Superphosphate..	400	11	1165	105	8	670	83	6	1045	174	19	19051	1003	..	....	....
	Kainit......	640	7	1430	204	5	828	165	3	475	158	..	...	....	11	15876	1443
4	Nitrate of Soda.........	160	7	850	121	5	1122	224	4	746	186	..	....	....	11	18144	1650
5	Check...........................		6	775	129	4	491	122	3	760	253	..	....	....	8	18144	2261
6	Salt	320	9	790	87	7	1125	160	5	793	158	..	....	....	17	24948	1467
7	Lime...................	8000	6	820	136	5	1040	208	3	655	218	..	....	....	9	15422	1713
8	Stable Manure.........	80000	9	885	98	6	974	162	4	525	131	..	....	....	9	10886	1209

TABLE V.

BEETS, LONG SMOOTH.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING											
			Number Harvested	July 20—Total Weight	Average Weight	Number Harvested	July 22 – Total Weight	Average Weight	Number Harvested	July 25 – Total Weight	Average Weight	Number Harvested	Sept. 20—Total Weight	Average Weight
1	Complete Fertilizer..................	560	4	425	106	3	655	218	2	290	145	8	9979	1247
2	Superphosphate	470	6	475	79	4	635	158	3	504	163	10	21773	2117
3	Kalnit................................	610	5	400	80	4	675	169	3	155	51	8	16783	2097
4	Nitrate of Soda..	160	8	630	78	5	590	138	4	170	42	12	18597	1549
5	Check		7	435	62	5	265	73	4	709	177	10	18144	1814
6	Salt..........................	320	6	508	84	4	300	75	3	524	174	10	21773	2177
7	Lime	8000	8	600	75	6	435	72	5	542	108	14	19051	1361
8	Stable Manure.........	80000	8	810	101	6	635	106	5	690	138	13	21319	1640

TABLE I.

ONIONS, SILVER KING.

No. of Plot	FERTILIZER	Amount per Acre	SEEDED					TRANSPLANTED				
			No. of Bulbs Seeded	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av. Weight per Bulb of Marketable	Number of Bulbs	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av. Weight per Bulb of Marketable
		LBS.										
1	Complete Fertilizer	560	47	250	37	242	7	50	496	50	496	9.1
2	Superphosphate	400	55	268	43	256	6	45	544	45	544	11.5
3	Kainit	640	60	319	46	334	7.3	48	528	48	528	11
4	Nitrate of Soda	160	43	263	39	256	7	44	528	44	528	12
5	Check		56	357	47	340	7.2	38	464	38	464	12.2
6	Salt	320	65	303	55	292	5.3	48	496	48	496	11.1
7	Lime	8000	52	302	47	296	6.3	47	440	47	440	9
8	Stable Manure	80000	32	186	28	180	6.5	36	360	36	360	10

TABLE II.

ONIONS, GIBRALTER.

Number of Plot	FERTILIZER	Amount per Acre	SEEDED					TRANSPLANTED				
			No. of Bulbs Seeded	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av. Weight per Bulb of Marketable	Number of Bulbs	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av. Weight per Bulb of Marketable
		LBS.										
1	Complete Fertilizer	560	55	417	42	400	9.5	42	688	42	688	14
2	Superphosphate	400	54	424	48	416	8.7	42	720	42	720	17.1
3	Kainit	640	40	344	35	336	9.3	31	624	31	624	20 1
4	Nitrate of Soda	160	55	443	46	432	9.4	43	680	43	680	16
5	Check		62	423	56	416	7.5	35	532	30	520	17
6	Salt	320	41	358	34	348	10.1	36	528	36	528	14.6
7	Lime	8000	13	128	13	124	9.5	40	592	40	592	14.8
8	Stable Manure	80000	0	0	0	0	0	90	432	29	432	15

TABLE III.

ONIONS, YELLOW GLOBE DANVERS.

Number of Plot	FERTILIZER	Amount per Acre	SEED D					TRANSPLANTED				
			No. of Bulbs Seeded	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av. Weight per Bulb of Marketable	Number of Bulbs	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av. Weight per Bulb of Marketable
		LBS.										
1	Complete Fertilizer	560	44	204	37	195	5.3	39	273	37	269	7.3
2	Superphosphate	400	52	193	39	177	4.5	37	263	37	263	7.1
3	Kainit	640	46	200	38	192	5	44	307	43	300	7
4	Nitrate of Soda	160	41	186	32	176	5.5	35	243	34	242	7.1
5	Check		41	202	36	196	5.5	38	227	37	226	6.1
6	Salt	320	39	148	31	140	4.5	36	206	36	206	5.8
7	Lime	8000	42	153	26	144	5.5	37	221	37	221	6
8	Stable Manure	80000	34	110	29	104	4	30	131	30	131	4.3

TABLE IV.

ONIONS, RED WEATHERSFIELD.

Number of Plot	FERTILIZER	Amount per Acre	SEEDED					TRANSPLANTED				
			No. of Bulbs Seeded	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av. Weight per Bulb of Marketable	Number of Bulbs	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av. Weight per Bulb of Marketable
		LBS.										
1	Complete Fertilizer	500	29	127	22	121	5.5	37	299	37	299	8.7
2	Superphosphate	400	46	224	35	212	6	21	164	21	162	7.7
3	Kainit	640	47	145	39	135	3.2	22	134	20	130	6.5
4	Nitrate of Soda	160	48	170	41	162	4	27	231	27	231	8.5
5	Check		47	179	37	167	4.3	25	211	25	211	8.4
6	Salt	320	43	172	33	160	4	22	134	22	134	6
7	Lime	8000	54	263	39	246	6.3	20	172	20	172	8.6
8	Stable Manure	80000	41	162	23	153	6.6	16	93	16	93	6

TABLE V.

ONIONS, SOUTHPORT YELLOW GLOBE.

Number of Plot	FERTILIZER	Amount per Acre	SEEDED					TRANSPLANTED				
			No. of Bulbs Seeded	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av Weight per Bulb of Marketable	Number of Bulbs	Weight per Plot	Number Marketable	Weight per Plot of Marketable	Av. Weight per Bulb of Marketable
		LBS.										
1	Complete Fertilizer	560	41	220	29	206	7.1	42	248	42	348	8.3
2	Superphosphate	400	43	239	33	225	7	36	307	33	298	9
3	Kainit	640	38	232	32	225	7	33	252	33	252	7.6
4	Nitrate of Soda	160	45	235	39	230	6	39	329	39	329	8.2
5	Check		37	175	24	169	7	36	309	36	309	8
6	Salt	320	25	158	22	153	7	39	378	39	378	9.7
7	Lime	8000	45	215	39	203	5.2	33	373	33	373	8.2
8	Stable Manure	80000	36	164	23	158	6.9	30	216	29	215	7.4

TABLE I.

CABBAGE, EARLY JERSEY WAKEFIELD.

Number of Plot	FERTILIZER.	Amount per acre	DATE OF PICKING.							
			No Head	July 14	No. Head	July 18	No Head	Aug. 4	Av. W't Per Plot per Season	Av. W't per Plot per Season for 1898
		LBS.								
1	Complete Fertilizer....	560	3	1095	1	1290	1	1927	1300	890
2	Superphosphate	400	4	1335	0		1	1532	1373	1177
3	Kainit...	640	3	981	1	1080	1	2312	1267	1251
4	Nitrate of Soda.......	160	2	1282	1	1035	1	1450	1262	1205
	Check.........		2	1092	3	14536	0		1309	1138
6	Salt..................	320	2	1362	0		3	1769	1575	1037
7	Lime.........	8000	1	1040	2	1360	2	17225	1441	1137
	Stable Manure........	80000	1	710	0	1170	2	1670	1305	1066

TABLE II.

CABBAGE, EARLY SUMMER.

No. of Plot	FERTILIZER.	Amount Per Acre	DATE OF PICKING.				Av. Wt. per Plot per Season.
			No. Head	Aug. 9.	No. Head	Aug. 23	
		LBS.					
1	Complete Fertilizer	560	3	1566	0		1566
2	Superphosphate......	400	2	2050	1	1741	1947
3	Kainit.....................	640	3	2433	0		2433
4	Nitrate of Soda....................	160	3	1713	1	2523	1916
5	Check.................		3	1440	1	3138	1845
6	Salt............................	320	2	1755	2	2157	2012
7	Lime...........	8000	2	1555	2	2854	2204
8	Stable Manure....................	80000	3	1709	1	3316	2111

TABLE I.

CUCUMBERS, WHITE WONDER.

No. of Plot	FERTILIZER	Amount per Acre LBS.	Date of First Picking	Total Weight per Plot per Season	Av. Weight per Vine per Season
1	Complete Fertilizer	560	Aug. 2	9774	1086
2	Superphosphate	400	Aug. 2	7849	1020
3	Kainit	640	Aug. 2	10845	1084
4	Nitrate of Soda	160	Aug. 2	18293	1076
5	Check		Aug. 2	11473	675
6	Salt	320	Aug. 2	15956	431
7	Lime	8000	Aug. 2	14177	567
8	Stable Manure	80000	Aug. 2	12441	912

TABLE II.

CUCUMBERS, HILLS FORCING.

No. of Plot	FERTILIZER	Amount per Acre LBS.	Date of First Picking	Total Weight per Plot per Season	Av. Weight per Vine per Season
1	Complete Fertilizer	560	Aug. 2	8937	554
2	Superphosphate	400	Aug. 2	7244	521
3	Kainit	640	Aug. 2	8412	525
4	Nitrate of Soda	160	Aug. 2	7910	506
5	Check		Aug. 2	8569	547
6	Salt	320	Aug. 2	5899	501
7	Lime	8000	Aug. 12	10307	748
8	Stable Manure	80000	Aug. 2	12160	592

TABLE I.

CABBAGE, EARLY JERSEY WAKEFIELD.

Number of Plot	FERTILIZER.	Amount per acre	DATE OF PICKING.							
			No Head	July 14	No. Head	July 18	No Head	Aug. 4	Av. W't Per Plot per Season	Av. W't per Plot per Season for 1898
		LBS.								
1	Complete Fertilizer....	560	3	1095	1	1290	1	1927	1300	890
2	Superphosphate	400	4	1335	0		1	1532	1373	1177
3	Kainit...	640	3	981	1	1080	1	2312	1267	1251
4	Nitrate of Soda.......	160	2	1282	1	1035	1	1450	1262	1205
	Check..........		2	1092	3	14536	0		1309	1138
6	Salt....................	320	2	1362	0		3	1769	1575	1037
7	Lime..........	8000	1	1040	2	1360	2	17225	1441	1137
8	Stable Manure........	80000	1	710	0	1170	2	1670	1305	1066

TABLE II.

CABBAGE, EARLY SUMMER.

No. of Plot	FERTILIZER.	DATE OF PICKING.					
		Amount Per Acre	No. Head	Aug, 9.	No. Head	Aug. 23	Av. Wt. per Plot per Season.
		LBS.					
1	Complete Fertilizer	560	3	1566	0		1566
2	Superphosphate......	400	2	2050	1	1741	1947
3	Kainit........................	640	3	2433	0		2433
4	Nitrate of Soda.....................	160	3	1713	1	2523	1916
5	Check..................		3	1440	1	3138	1845
6	Salt..............................	320	2	1755	2	2157	2012
7	Lime.............	8000	2	1555	2	2854	2204
8	Stable Manure...................	80000	3	1709	1	3316	2111

TABLE III

CABBAGE, DANISH BALL HEAD.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING				
			Number Head	Aug. 17	Number Head	Aug. 25	Av. Weight per Plot per Season
		LBS.					
1	Complete Fertilizer.............	560	3.	1627	1	2020	1725
2	Superphosphate.............. ..	400	2	1485	1	2135	1701
3	Kainit...........................	640	2	1442	1	2732	2808
4	Nitrate of Soda.........	160	3	1670	0		1670
5	Check............		3	1782	2	1906	2062
6	Salt	320	3	1647	1	1417	1589
7	Lime...............	8000	2	1460	1	1175	1365
8	Stable Manure..................	80000	2	1522	2	1323	1423

TABLE IV.

CABBAGE, SUCCESSION.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING				
			Number Head	Aug. 4	Number Head	Aug. 17	Av. Weight per Plot per Season
		LBS.					
1	Complete Fertilizer..............	560	0	....	3	2951	2951
2	Superphosphate.................	400	2	1366	2	2487	1924
3	Kainit............................	640	3	1342	0		1342
4	Nitrate of Soda........	160	3	2155	0		2155
5	Check............................		2	2012	2	2797	2404
6	Salt	320	2	2535	1	3195	2755
7	Lime.................	8000	1	2415	2	3245	2968
8	Stable Manure.........	80000	2	1757	1	3305	2273

TABLE V.

CABBAGE, MARBLEHEAD MAMMOTH.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING				
			Number Head	Aug. 17	Number Head	Aug. 25	Av. Weight per Plot per Season
		LBS.					
1	Complete Fertilizer...............	560	2	1957	1	2753	2223
2	Superphosphate	400	2	2290	1	2799	2689
3	Kainit............................	640	0	....	1	5942	5942
4	Nitrate of Soda	160	1	1855	2	1741	1779
5	Check		2	2480	1	2318	2426
6	Salt..............................	320	0	....	2	3059	3059
7	Lime..............................	8000	0	....	1	2580	2580
8	Stable Manure.....................	80000	3	1508	1	2823	1837

TABLE VI.

CABBAGE, ALL HEAD.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING				
			Number Head	Aug. 10	Number Head	Aug. 22	Av. Weight per Plot per Season
		LBS.					
1	Complete Fertilizer...............	560	3	1734	1	1346	1662
2	Superphosphate....................	400	4	1487	0	....	1487
3	Kainit............................	640	4	1553	0	....	1553
4	Nitrate of Soda...................	160	3	1449	1	2218	1641
5	Check		4	2140	0	....	2140
6	Salt..............................	320	3	1481	1	3761	2061
7	Lime	8000	3	1770	0	....	1770
8	Stable Manure.....................	80000	3	1702	0	....	1702

TABLE VII.

CABBAGE, WASHINGTON WAKEFIELD.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING						
			No. Head	July 14	No. Head	July 17	No. Head	July 19	Av. W't per Plot per Season.
		LBS.							
1	Complete Fertilizer.......... ..	560	3	1483	1	1375	0		1441
2	Superphosphate................	400	3	1308	1	1480	0		1351
3	Kainit	640	3	1315	0		1	1510	1363
4	Nitrate of Soda...............	160	3	1363	1	1270	0		1340
5	Check		3	1265	1	1420	0		1303
6	Salt	320	2	1007	2	870	0		930
7	Lime	8000	1	1105	3	1116	0		1113
8	Stable Manure.................	80000	1	925	0		3	1203	1133

TABLE VIII.

CABBAGE, EARLY SPRING

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING							
			No. Head	July 17	No. Head	July 19	No. Head	Aug. 4	Av. Weight per Plot per Season	Av. Weight per Plot per Season for '9
		LBS.								
1	Complete Fertilizer ..	560	4	1980	0	..	1	3505	2285	1178
2	Superphosphate......	400	2	1580	2	1572	1	3660	2091	1310
3	Kainit	640	4	2005	0	....	1	2410	2086	1316
4	Nitrate of Soda.......	160	4	2050	0	....	1	1595	1959	1283
5	Check		2	2215	2	1817	1	3530	2319	1227
6	Salt..................	320	4	1961	0	....	1	3090	2187	1338
7	Lime	8000	1	1660	2	1761	1	2220	1851	1239
8	Stable Manure........	80000	2	1715	2	1567	1	2845	1882	1449

TABLE 1.

LETTUCE, PRIZEHEAD.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING							
			SEEDED					TRANSPLANTED		
			June 30	July 11	July 15	July 18	Av. Weight per Plot per Season			
1	Complete Fertilizer	LBS. 560	97.5	391	418	551.6	308.4	......	......	......
2	Superphosphate	400	100.7	391	502	458.3	341.3	......	......	......
3	Kainit	640	94.7	326	436	496.6	276.5	......	......	......
4	Nitrate of Soda	160	79.4	485.5	487	505	330.9	......	......	......
5	Check		91	469.5	508	475	331 3	......	......	......
6	Salt	320	125.1	418.5	477.2	582.5	368.3	......	......	......
7	Lime	8000	84.3	453.3	431	575	339.4	......	......	......
8	Stable Manure	80000	21 5	311	485	625	299.4	......	......	......

TABLE II.

LETTUCE, THICK HEAD YELLOW.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING				
			SEEDED			TRANSP'T'D	
			July 13	July 15	Av. Weight per Plot per Season	July 15	Av. Weight per Plot per Season
		LBS.					
1	Complete Fertilizer........	560	452	400	437.1	507.5	507.5
2	Superphosphate............. ..	400	454	507.5	483.5	452.5	452.5
3	Kainit......................	640	268	390	302.8	450	450
4	Nitrate of Soda.........	160	348	415	367.1	580	580
5	Check.........................		578.1	232.5	478.2	537.5	537.5
6	Salt	320	300	350	328.5	455	455
7	Lime..........................	8000	427.5	505	455.8	452.5	452.5
8	Stable Manure.	30000	447.5	415	453.3	457.5	457.5

TABLE III.

LETTUCE, DWARF WHITE HEART.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING							
			SEEDED				TRANSPLANTED			
			July 5	July 15	Av. Weight per Plot per Season	Av. Weight per Plot per Season for '98	July 5	July 8	Av. Weight per Plot per Season	Av. Weight per Plot per Season for '98
1	Complete Fertilizer....	LBS. 560	212	412 5	269.2	205	515	592.5	540.8	588
2	Superphosphate	400	151.7	496	266.5	280	327.5	542.5	399.1	632
3	Kainit.....	640	199	476	278.1	319	487.5	430	468.3	612
4	Nitrate of Soda............	160	176.25	630	327.5	358	508.7	510	505.8	609
5	Check		150.25	510	255	330	481.2	507.5	490	554
6	Salt...	320	185	365	236.4	280	426.2	570	474.1	626
7	Lime..	8000	100.5	462.5	181.1	323	450	470	456.6	760
8	Stable Manure......	80000	145.5	662.5	317.8	308	386.2	530	434.1	783

TABLE IV.

LETTUCE, GIANT WHITE COS.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING							
			SEEDED				TRANSPLANTED			
			July 10	July 15	Av. Weight per Plot per Season	Av. Weight per Plot per Season for '98	July 5	July 8	Av. Weight per Plot per Season	Av. Weight per Plot per Season for '98
		LBS.								
1	Complete Fertilizer	560	314	410	341.1	185	491.7	592.5	525	778
2	Superphosphate	400	291.6	365	310	186	420	537.5	459.1	698
3	Kainit	640	300	327.5	309.1	206	407.5	447.5	421.1	625
4	Nitrate of Soda	160	335.8	357.5	341	292	330	535	398.3	730
5	Check		350	375	355.6	284	481.2	550	504.1	731
6	Salt	320	255.8	392.5	290	230	435	500	456.6	744
7	Lime	8000	310	372.5	327.8	273	408.7	517.5	445	530
8	Stable Manure	80000	245	325	287.8	363	423.2	525	457.5	842

TABLE V.

LETTUCE, DENVER MARKET.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING				
			SEEDED			TRANSP'T'D	
			July 10	July 15	Av. Weight per Plot per Season	July 5	Av. Weight per Plot per Season
		LBS.					
1	Complete Fertilizer	560	296	560	371.4	575	575
2	Superphosphate	400	266	562.5	351.2	442.5	442.5
3	Kainit	640	634	355	334.8	506.5	506.5
4	Nitrate of Soda	160	240	372.5	282.1	557.5	557 5
5	Check		249	475	313.4	467.5	467.5
6	Salt	320	245	370	280.7	452.5	452.5
7	Lime	8000	290	545	362.8	427.5	427.5
8	Stable Manure	80000	241	560	332.1	350	350

TABLE VI.

LETTUCE, EARLY CURLED SILISIA.

Number of Plot.	FERTILIZER	Amount per Acre	DATE OF PICKING				
			SEEDED			TRANSP'T'D	
			July 10	July 14	Av. Weight per Plot per Season	July 1	Av. Weight per Plot per Season
		LBS.					
1	Complete Fertilizer	560	330	430	357.1	572.5	572.5
2	Superphosphate	400	334	455	368.5	632.5	632.5
3	Kainit	640	370.8	355	366.8	657.5	657.5
4	Nitrate of Soda	160	307	417.5	323 5	685	685
5	Check		339	370	347.8	622 5	622.5
6	Salt	320	333	682.2	432.8	675	675
7	Lime	8000	304.5	415	340	600	600
8	Stable Manure	80000	242	425	294.2	680	680

TABLE I.

TOMATOES, DWARF CHAMPION.

No. of Plot	FERTILIZER	Amount per Acre	Date of First Ripe Fruit	Total Weight of Plot per Season	Av. Weight per Vine per Season
		LBS.			
1	Complete Fertilizer	560	Aug. 9	6722	1680
2	Superphosphate	400	Aug. 3	4537	1134
3	Kainit	640	Aug. 9	6909	1727
4	Nitrate of Soda	160	Aug. 3	7089	1772
5	Check		Aug. 9	6071	1517
6	Salt	320	Aug. 9	8420	2105
7	Lime	8000	Aug. 3	4979	1244
8	Stable Manure	80000	Aug. 3	6860	1715

TABLE II.

TOMATOES, EARLIEST OF ALL.

No. of Plot	FERTILIZER	Am't per Acre	Date of First Ripe Fruit	Total W't of Plot per Season	Average W't Per Vine per Season
		LBS.			
1	Complete Fertilizer	560	July 31	5845	1461
2	Superphosphate	400	July 31	9234	2308
	Kainit	640	July 31	10960	2765
4	Nitrate of Soda	160	July 31	10526	2631
5	Check		July 31	15414	3853
6	Salt	320	July 31	15229	3807
7	Lime	8000	July 31	16182	4045
8	Stable Manure	80000	July 31	14797	3690

TABLE III.

TOMATOES, COMBINATION.

No. of Plot	FERTILIZER	Amount per Acre LBS.	Date of First Ripe Fruit	Total Weight of Plot per Season	Av. Weight per Vine per Season
1	Complete Fertilizer	560	Aug. 4	14230	3557
2	Superphosphate	400	Aug. 4	19500	4875
3	Kainit	640	Aug 4	21542	5385
4	Nitrate of Soda	160	Aug. 4	18359	4589
5	Check		Aug. 4	10230	1557
6	Salt	320	Aug. 11	10936	4234
7	Lime	8000	Aug. 4	16010	4002
8	Stable Manure	80000	Aug. 4	15729	3932

TABLE IV.

TOMATOES, FERRIS WHEEL.

No. of Plot	FERTILIZER	Amount per Acre LBS.	Date of First Ripe Fruit	Total Weight of Plot for Season	Av. Weight per Vine per Season
1	Complete Fertilizer	590	Aug. 11	9176	2294
2	Superphosphate,	400	Aug. 11	11844	2961
3	Kainit	640	Aug. 21	12936	3234
4	Nitrate of Soda	160	Aug. 11	11162	2790
5	Check		Aug. 3	18963	4741
6	Salt	320	Aug. 3	21308	5327
7	Lime	8000	Sept. 4	7767	1942
8	Stable Manure	80000	Aug. 21	14756	368,

TABLE V.

TOMATOES, FORDHOOK FIRST.

No. of Plot	FERTILIZER	Amonnt per Acre	Date of First Ripe Fruit	Total Weight of Plot per Season	Av. Weight per Vine per Season
1	Complete Fertilizer	LBS. 560	Aug. 24	8809	2202
2	Superphosphate	400	Aug. 11	13742	3435
3	Kainit	640	Aug. 4	17997	4499
4	Nitrate of Soda	160	Aug. 11	14387	3597
5	Check		Aug. 4	10650	2662
6	Salt	320	Aug. 11	12724	3181
7	Lime	8000	Aug. 18	14628	3657
8	Stable Manure	80000	Aug. 4	8691	2173

TABLE VI.

TOMATOES, EARLY MICHIGAN.

No. of Plot	FERTILIZER	Amount per Acre	Date of First Ripe Fruit	Total Weight of Plot per Season	Av. Weight per Vine per Season
1	Complete Fertilizer	LBS. 560	Aug. 24	11003	2751
2	Superphosphate	400	Aug. 9	14072	3518
3	Kainit	140	Aug. 9	13429	3357
4	Nitrate of Soda	160	Aug. 9	10840	2710
5	Check		Aug. 9	12134	3033
6	Salt	320	Aug. 4	14024	3506
7	Lime	8000	Aug. 9	18018	4504
8	Stable Manure	80000	Aug. 9	14059	3514

TABLE VII.

TOMATOES, NEW IMPERIAL.

No. of Plot	FERTILIZER	Amount per Acre LBS.	Date of First Ripe Fruit	Total Weight of Plot per Season	Av. Weight per Vine per Season
1	Complete Fertilizer	560	Aug. 9	14415	3603
2	Superphosphate	400	Aug. 9	9655	2413
3	Kainit	640	Aug. 9	12471	3142
4	Nitrate of Soda	160	Aug. 24	10696	2674
5	Check		Aug. 9	11026	2756
6	Salt	320	Aug. 16	9994	2498
7	Lime	8000	Aug. 9	10721	2680
8	Stable Manure	80000	Aug. 9	12074	3018

TABLE VIII.

TOMATOES, EARLY MINNESOTA.

No. of Plot	FERTILIZER	Amount per Acre LBS.	Date of First Ripe Fruit	Total Weight of Plot per Season	Av. Weight per Vine per Season
1	Complete Fertilizer	560	Aug. 4	19384	4846
2	Superphosphate	400	Aug. 4	15291	3822
3	Kainit	640	Aug. 4	18500	4625
4	Nitrate of Soda	160	Aug. 4	21364	5341
5	Check		Aug. 4	19743	4935
6	Salt	320	Aug. 4	23238	5809
7	Lime	8000	Aug. 4	21950	5487
8	Stable Manure	80000	Aug. 4	16707	4176

TABLE IX.

TOMATOES, FORDHOOK FANCY.

No. of Plot	FERTILIZER	Amount per Acre	Date of First Ripe Fruit	Total Weight per Plot per Season	Av. Weight per Vine per Season
		LBS.			
1	Complete Fertilizer	560	Aug. 9	7500	1875
2	Superphosphate	400	Aug. 9	8766	2191
3	Kainit	640	Aug. 9	8634	2158
4	Nitrate of Soda	160	Aug. 15	8518	2129
5	Check		Aug. 9	7740	1935
6	Salt	320	Aug. 9	6835	1708
7	Lime	8000	Aug. 3	8369	2092
8	Stable Manure	80000	Aug. 3	7324	1081

TABLE I.

BEANS, REFUGEE.

Number of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING		
			August 14	August 27	Av. Weight per Vine per Season
		LBS			
1	**Complete Fertilizer**	560	48	48	97
2	**Superphosphate**	400	102	51	153
3	**Kainit**	640	46	42	89
4	**Nitrate of Soda**	160	66	29	86
5	**Check**		71	115	186
6	**Salt**	320	31	138	143
7	**Lime**	8000	32	118	150
8	**Stable Manure**	80000	27	97	124

TABLE II.

BEANS, VALENTINE WAX.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING						
			July 21	July 26	July 31	Aug. 5	Aug. 14	Av. Weight per Vine per Season	Av. Weight per Vine per Season for '98
		LBS.							
1	Complete Fertilizer	560	15	40	43	19	44	160	168
2	Superphosphate	400	8	39	39	26	43	155	152
3	Kainit	640	14	34	41	19	31	136	137
4	Nitrate of Soda	160	20	45	44	20	33	204	168
5	Check		30	59	56	22	40	208	148
6	Salt	320	29	55	40	14	24	181	147
7	Lime	8000	27	59	60	31	48	225	116
8	Stable Manure	80000	23	63	50	24	37	197	117

TABLE III.

BEANS, NEW STRINGLESS.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING							
			July 22	July 27	July 29	July 31	August 5	August 15	Av. Weight per Vine per Season	Av. Weight per Vine per Season for 1898
		LBS.								
1	Complete Fertilizer	560	18	46	18	17	31	43	174	139
2	Superphosphate	400	8	32	22	28	39	64	193	152
3	Kainit	640	12	39	18	18	24	46	158	260
4	Nitrate of Soda	160	12	28	10	16	17	55	136	273
5	Check		26	46	16	23	14	36	159	261
6	Salt	320	20	39	15	18	16	35	213	215
7	Lime	8000	27	40	25	20	31	68	144	156
8	Stable Manure	80000	40	59	20	11	16	33	180	169

TABLE IV.

BEANS, YOSEMITE MAMMOTH.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING					
			July 27	July 29	Aug. 5	Aug. 12	Aug. 22	Av. Weight per Vine per Season
		LBS						
1	Complete Fertilizer	560	13	9	41	26	61	152
2	Superphosphate	400	18	6	56	44	86	201
3	Kainit	640	14	45	32	36	53	237
4	Nitrate of Soda	160	13	9	51	36	50	171
5	Check		38	15	54	33	31	172
6	Salt	320	39	8	57	31	25	181
7	Lime	8000	31	11	42	24	23	133
8	Stable Manure	80000	45	13	47	45	46	176

TABLE V.

BEANS, EARLY RED VALENTINE.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING						
			July 24	July 27	July 29	July 31	Aug. 5	Aug. 15	Av. Weight per Vine per Season
		LBS.							
1	Complete Fertilizer	560	24	18	18	19	28	62	168
2	Superphosphate	400	10	17	17	18	21	57	141
3	Kainit	640	8	12	13	12	18	37	109
4	Nitrate of Soda	160	15	15	9	11	18	34	124
5	Check		26	22	16	17	21	49	187
6	Salt	320	31	26	15	18	17	35	122
7	Lime	8000	24	15	12	18	35	51	156
8	Stable Manure	80000	32	30	13	17	23	44	159

TABLE I.

RADISH, BURPEE'S EARLIEST.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING				
			June 15—Av. Weight per Root with Leaves	June 19—Av. Weight per Root with Leaves	Av. Weight per Plot per Season, with Leaves	Av. Weight per Plot per Season, without Leaves	Av. Wt. per Plot per Season with Leaves, for 1898
1	Complete Fertilizer	LBS. 560	13.3	16.2	15.4	10.5	12.4
2	Superphosphate	400	12.7	19.4	16	10.8	22.4
3	Kainit	640	15.3	12.8	13.6	9.5	16.6
4	Nitrate of Soda	160	12.5	13.2	13	8.7	13.5
5	Check		12.4	13.4	13.1	9.8	12.5
6	Salt	320	16	17.1	16.7	11.4	17
7	Lime	8000	17.2	14	15.4	10.8	11.5
8	Stable Manure	80000	12	15.4	14	9.8	23

TABLE II.

RADISH, CINCINNATI MARKET.

No. of Plot	FERTILIZER	Amount per Acre	DATR OF PICKING				
			June 16—Av. Weight per Root, with Leaves	June 19—Av. Weight per Root, with Leaves	June 24—Av. Weight per Root, with Leaves	Av. Wt. per Plot per Season, with Leaves	Av. Wt. per Plot per Season, without Leaves
1	Complete Fertilizer	LBS. 560	28	24.6	47	35.6	21.2
2	Superphosphate	400	28.8	29.2	42.5	34.2	21.1
3	Kainit	640	28.1	27.5	46.4	36.5	20.9
4	Nitrate of Soda	160	32.3	26.6	44	37	20.9
5	Check		26.8	28.3	48.5	35.05	21.3
6	Salt	320	16.9	32.9	47.2	13.1	20.9
7	Lime	8000	15.3	30	52.8	33	20.2
8	Stable Manure	80000	13.7	28.5	53.8	36.8	21.5

TABLE III.

RADISH, EARLIEST WHITE.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING			
			June 15—Av. Weight per Root, with Leaves	June 19—Av. Weight per Root, with Leaves	Av. Wt. per Plot per Season, with Leaves	Av. Wt. per Plot per Season, without Leaves
		LBS				
1	Complete Fertilizer	560	22.7	24.5	23.9	18.3
2	Superphosphate	400	22.1	26.5	21.5	19.6
3	Kainit	640	24.7	23.3	25.7	20
4	Nitrate of Soda	160	22.8	23.1	23	17.7
5	Check		22.9	24.2	23.8	18.3
6	Salt	320	23.5	24.6	24.2	18.9
7	Lime	8000	20.4	21.7	21.1	16.7
8	Stable Manure	80000	17.3	19.8	18.7	12.3

TABLE IV.

RADISH, EARLY SCARLET TURNIP.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING			
			June 16—Av. Weight per Root with Leaves	June 19—Av. Weight per Root with Leaves	Av. Wt. per Plot per Season, with Leaves	Av. Wt. per Plot per Season, without Leaves
		LBS.				
1	Complete Fertilizer	560	18.9	15.1	16.4	12.5
2	Superphosphate	400	16.8	15.2	15.7	11.8
3	Kainit	640	17.3	13.8	15.2	11.3
4	Nitrate of Soda	160	15.6	13.6	14.4	10.4
5	Check		17.8	13.9	14.9	11.3
6	Salt	320	15.1	13.6	14.1	10.1
7	Lime	8000	15.7	12.7	14.2	10.4
8	Stable Manure	80000	14.5	14	14.3	10.8

TABLE V.

RADISH, EARLY SCARLET GLOBE.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING			
			June 15—Av. Weight per Root, with Leaves	June 19—Av. Weight per Root with Leaves	Av. Wt. per Plot per Season, with Leaves	Av. Wt. per Plot per Season, without Leaves
		LBS.				
1	Complete Fertilizer	560	16.2	11.5	15.4	11.1
2	Superphosphate	400	14.6	14.8	12.7	9.6
3	Kainit	640	16.7	15.5	15.8	11.5
4	Nitrate of Soda	160	16	15.7	15.8	11.9
5	Check		17	15.7	16.2	11.9
6	Salt	320	15.7	15.2	15.4	11.3
7	Lime	8000	13	13.3	13.1	9.6
8	Stable Manure	80000	15.7	12.8	14.1	10.5

TABLE I.

PEAS, FIRST OF ALL

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING		
			July 21—Av. Weight per Vine	July 27—Av. Weight per Vine	Av. Weight per Vine per Season
		LBS.			
1	Complete Fertilizer	560	48.2	6	53.4
2	Superphosphate	400	55.3	11.7	65.8
3	Kainit	640	26.7	7	33
4	Nitrate of Soda	160	43.5	8.3	51.2
5	Check		49.2	7.5	56.5
6	Salt	320	58	13	71
7	Lime	8000	38	3.9	41.8
8	Stable Manure	80000	48	5.3	51.6

TABLE II.

PEAS, GRADUS.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING		
			July 21—Av. Weight per Vine	July 27—Av. Weight per Vine	Av. Weight per Vine per Season
		LBS.			
1	Complete Fertilizer	560	47.5	9.5	57
2	Superphosphate	400	51.5	8	59.5
3	Kainit	640	75	15	90
4	Nitrate of Soda	160	31.7	8.5	40.2
5	Check		52.5	3.8	55
6	Salt	320	46.6	10.8	67.4
7	Lime	8000	66.4	1.9	68.3
8	Stable Manure	80000	52.5	8.3	53.3

TABLE III.

PEAS, ADVANCE.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING			
			Aug. 16—Av. Weight per Vine	Aug. 25—Av. Weight per Vine	Av. Weight per Vine per Season	Av. Wt. per Vine per Season for '98
		LBS.				
1	Complete Fertilizer	560	24.5	20.9	45.4	62
2	Superphosphate	400	19.2	19	38.2	51
3	Kainit	640	21.1	13.8	34.9	45
4	Nitrate of Soda	160	14.1	14.2	28.3	46
5	Check		15 4	15.5	30.9	30
6	Salt	320	19.1	10.8	29.9	
7	Lime	8000	18.5	12 7	31.2	45
8	Stable Manure	80000	27.4	10.3	37.7	66

TABLE IV.

PEAS, LITTLE GEM.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING		
			Aug. 16—Av. Weight per Vine	Aug. 25—Av. Weight per Vine	Av. Wt. per Vine per Season
		LBS.			
1	Complete Fertilizer	560	33.2	19.1	52 2
2	Superphosphate	400	21.3	14 7	39
3	Kainit	640	27.4	13	40.4
4	Nitrate of Soda	160	25	16.6	41.6
5	Check		39.3	19.6	57.9
6	Salt	320	23	13.6	36.6
7	Lime	8000	25 7	19.3	45
8	Stable Manure	80000	25.7	19 3	45

TABLE I.

CARROTS, GOLDEN BALL.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING											
			Total No. Harvested	July 24—Total Wt. of Marketable	Total Weight of Un-marketable	Average Weight of Marketable	Total No. Harvested	July 25—Total Weight of Marketable	Total Weight of Un-marketable	Average Wt. of Mar-ketable	Total No. Harvested	Aug. 28—Total Weight Marketable	Total Weight of Un-marketable	Average Weight of Marketable
		LBS.												
1	Complete Fertilizer	560	20	290	67	22	14	306	26	28	35	3386	860	164
2	Superphosphate	400	16	360	20	28	12	333	6	30	34	3890	1021	174
3	Kainit	640	15	200	31	20	10	235	5	26	..	..	....	...
4	Nitrate of Soda	160	15	219	25	20	12	254	5	23	34	3990	765	117
5	Check		14	270	15	25	10	175	19	25	27	3081	835	171
6	Salt	320	14	260	10	22	12	278	4	28	27	2986	490	166
7	Lime	8000	15	329	0	22	11	240	15	27	30	3926	440	164
8	Stable Manure	80000	12	265	5	24	9	237	5	28	23	2896	270	160

TABLE II.

CARROTS

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING											
			Total No. Harvested	July 22, Total Weight of Marketable	Total W't of Unmarketable	Av. W't of Marketable	Total No. Harvested	July 28, Total, Weight of Marketable	Total W't of Marketable	Av. W't of Unmarketable	Total No. Harvested	Aug. 26, Total Weight of Marketable	Total W't of Unmarketable	Av. W't of Marketable
1	Complete Fertilizer	LBS. 560	27	397	150	28	20	528	0	26	55	5338	483	121
2	Superphosphate	400	29	545	53	25	21	517	17	28	74	8008	460	139
3	Kainit	640	26	477	74	25	21	654	10	33	...	......	......	......
4	Nitrate of Soda	160	32	502	47	22	27	489	32	21	65	5967	866	127
5	Check		34	462	52	19	22	345	89	25	70	6246	653	112
6	Salt	320	38	611	68	24	26	514	57	25	74	5713	1288	124
7	Lime	8000	29	447	124	20	20	373	42	27	52	4577	800	130
8	Stable Manure	80000	30	440	45	20	22	468	68	26	43	4117	501	124

TABLE III.

CARROTS, MODEL.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING											
			Total No. Harvested.	July 24, Total Weight of Marketable	Total W't of Unmarketable	Av. W't of Marketable	Total No Harvested	July 25, Total Weight of Marketable	Total W't of Unmarketable	Av. W,t of Marketable	Total No. Harvested	Aug. 28, Total Weight of Unmarketable	Total W't of Marketable	Av. W't of Marketable
		LBS.												
1	Complete Fertilizer	560	21	650	20	36	14	545	0	39	37	6209	142	182
2	Superphosphate	400	25	800	20	36	17	545	7	34	62	10472	173	184
3	Kainit	640	27	717	24	31	18	717	0	40	...	......	....	....
4	Nitrate of Soda	160	21	635	7	32	15	514	24	43	36	8079	0	224
5	Check		22	652	3	31	14	372	17	31	44	7875	476	208
6	Salt	320	29	625	15	24	19	384	52	30	51	8974	0	176
7	Lime	8000	26	724	9	30	18	442	20	30	47	6870	0	146
8	Stable Manure	80000	19	432	19	27	12	335	40	34	31	6353	120	235

TABLE IV.

CARROTS, NEW MEAUX.

No. of Plot	FERTILIZER	Amount per Acre	DATE OF PICKING											
			Total No. Harvested	July 24, Total Weight of Marketable	Total W't of Unmarketable	Av. W't of Marketable	Total No. Harvested	July 25, Total Weight of Marketable	Total W't of Unmarketable	Av. W't of Marketable	Total No. Harvested	Aug. 28 Total Weight of Marketable	Total W't of Unmarketable	Av. W't of Marketable
1	Complete Fertilizer	LBS. 560	16	412	12	28	11	340	0	31	26	5792	0	223
2	Superphosphate	400	19	530	20	35	14	380	20	32	33	6936	0	210
3	Kainit	640	18	365	42	30	11	269	29	35	...	......	.....	.....
4	Nitrate of Soda	160	19	645	40	50	14	327	0	23	38	7286	0	192
5	Check		12	285	85	35	9	242	25	40	24	5661	0	236
6	Salt	320	13	375	6	31	9	223	0	32	22	4377	0	198
7	Lime	8000	12	250	5	23	8	172	19	29	23	4860	0	211
8	Stable Manure	80000	12	262	10	26	9	217	12	21	24	4650	672	258

GENERAL
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JUN 8 1900

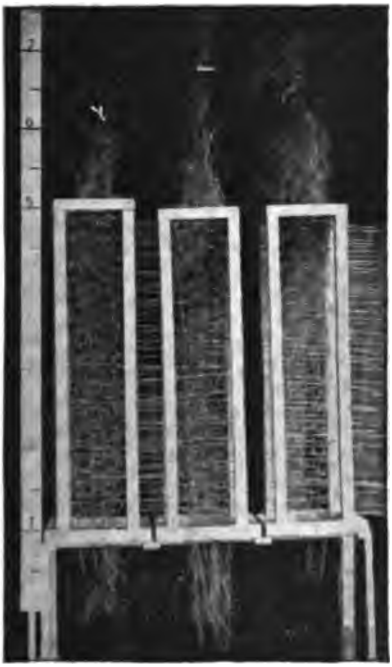
NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.



Bulletin No. 43.

A STUDY OF THE ROOT SYSTEMS OF CULTIVATED PLANTS GROWN AS FARM CROPS.

Any farmer in the state can have the bulletins of the Station mailed to his address, free of charge, upon application.

Fargo, North Dakota, U. S. A
March, 1900.

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ROOTS OF PLANTS.

A STUDY OF THE ROOT SYSTEMS OF CULTIVATED PLANTS GROWN AS FARM CROPS.

In the summer of 1898, experiments were begun at this Station with the object of studying the root development of our common cultivated plants. Bulletin No. 36, published in January, 1899, is the report of the first year's work. In this "preliminary" report the roots of wheat, oats and corn received special attention. Some discussion was made on the root systems of flax, potatoes and sugar beets, but the study of the roots of these plants was not considered satisfactory at that time, and has been repeated and extended during the past season. The roots of grasses, especially Bromus inermis, have also received some attention.

The present bulletin is mainly a report of the work done in 1899, including a brief review of the study of the roots of wheat, oats and corn, and of the manner in which the root samples are prepared.

A brief summary of the root work done at this Station is published in the Proceedings of the Tri-State Grain Growers' Convention, held in Fargo in January, 1900. In the preparation of the present report, I have quoted frequently from the former publication.

THE MANNER IN WHICH THE ROOT SAMPLES ARE PREPARED.

The plan of the work and manner of taking the roots are fully described in bulletin No. 36. Briefly, the samples are prepared as follows: Dig a trench two feet wide about a block of earth in which is growing the plant or plants, the roots of which it is desired to secure as a sample. Fit closely over this block of earth a cage, made by covering the sides and ends of a wooden or iron frame of the proper dimensions with common wire poultry netting. When the cage is properly fitted so that the top part of the frame rests firmly on the ground, plaster of Paris stirred to a thin paste with water, is poured into the top of the frame about the base of the plants, until it is one and one-half to two inches thick and allowed to set and harden. Small wire rods (Nos. 10 and 12 galvanized iron or copper wire straightened and cut into pieces about two inches longer than the cage is wide, sharpened at one end and looped at the other) are now run through the block of earth the shortest way, or better, two ways when the cage is square, and made secure at one end. Water by means of a small force or spray pump is now applied and the dirt is slowly washed away, leaving the roots suspended on the wire rods.

The frames of the cages illustrated are made out of two-inch stuff and are twelve to sixteen inches square, or about that width in the long cages. This is as thick a block of earth as the rods can be shoved through easily. It will be perceived that this plan will not work successfully in a soil which is loose or inclined to cave. The method requires no artificial preparation of the soil previous to planting the crop. Samples prepared in this way show the actual development and distribution of the roots which take place under natural field conditions.

WHEAT ROOTS.

Fig. 1 shows a sample of wheat roots taken at maturity, one hundred and ten days after the seed was planted. The wheat is a variety of Scotch fife, known as Experiment Station 66. The sample shows a good height of straw, the heads are well filled and the wheat is plump and hard. The soil in which the sample grew has been cropped twelve years—mostly with wheat. The ground was fall plowed. The wheat was sown in drills six inches apart and given ordinary treatment.

The first thing noticed in the sample is the depth to which the roots penetrate, i. e., four feet into the soil. This was the length of the cage and was as deep as the roots were washed out. I venture to affirm, however, that many roots went a foot or two deeper. When the sample was taken the depth of the water table in that field was six and one-half feet. The roots of the wheat must have reached very nearly to the surface of the water-filled soil.

The main roots of the wheat grow almost vertically downwards, giving off numerous small branches and feeders, which practically occupy the soil to the depth shown. In the upper part of the soil, the branches form a fine network clearly shown in the figure. All of the deep roots are slender and thread-like and nearly uniform in diameter throughout their length, notwithstanding the fact that they give off many branches almost equal to themselves in size. The roots are given off from the base of the root stock in the form of whorls or circles. Those of the upper whorls curve outward before striking downward into the soil, acting somewhat as brace roots.

Diagram No. 1 represents the main root system of a single stool of wheat. The drawing was made after studying a sample of wheat roots taken just as the wheat was heading. This wheat had been planted in drill rows eighteen inches apart, so that the roots had plenty of room. At this time, eighty days after planting, the roots were found to have reached a depth of three feet and to have spread horizontally, nearly nine inches on each side of the row so that practically all of the ground was occupied.

OAT ROOTS.

Oat roots are similar to wheat roots but larger and more numerous, making a greater fibrous growth in the upper part of the soil and extending fully as deep into the ground.

It is a fact noted by farmers, that oat ground, during the time of plowing, often turns up looser and mellower than wheat ground. This difference is doubtless due to the greater growth of roots by the oats near the surface.

CORN ROOTS.

Several samples of corn roots have been taken at different stages of growth. Thirty days after planting, at the second cultivation, the roots from adjacent hills (hills three feet apart) already meet and interlace. The main development in the early part of the season is laterally or to the side. A few roots have reached a depth of twelve inches, but the bulk of the growth is within eight inches of the surface of the ground. Six inches from the hill the main roots lie within two and one-half to three inches of the surface. Midway between the hills they have reached a depth of four and one-half inches. Deep cultivation even at this stage of growth would have injured the roots.

The sample of corn roots taken fifty-five days after planting, at the last cultivation, shows that at this stage the main roots have penetrated to the depth of two and one-half feet. The number of horizontal roots has increased and their length is much greater, many extending now from hill to hill (three feet, eight inches apart), inclining most of their length, but finally, at about three to three and one-half feet from the hill, they dip often almost vertically downward. The horizontal roots, as well as the vertical, send out numerous branches and small feeders in all directions. Many vertical branches from the horizontal roots have penetrated the hard layer of soil beneath the furrow slice and have already reached depths almost equal to those of the primary vertical roots. The branches in turn give off other branches and these produce fibers and root hairs so that the whole soil at this stage of growth to the depth of two feet was practically filled with roots. In this sample the main roots were three inches from the surface of the ground at six inches from the hill and about four inches below the surface midway between the rows. Numerous feeders or small fibrous roots were noticed in washing, within two inches of the surface, and some were caught on the wires. After corn is ten inches high, it should not be cultivated deep. A sample of corn roots taken after the corn was killed by frost, ninety days after planting, showed that the whole field to the depth of three, and a half feet was fully occupied by the roots. See Fig.3.

FLAX ROOTS.

In Fig. 2 is shown a sample of flax roots which was taken eighty-seven days after planting, just as the crop was ready to cut for seed. (Variety, common seed flax.) The average length of straw in this sample is twenty-six inches. The heads are large and the bolls are well filled. The sample grew in soil which has been cropped for sixteen years, mostly with wheat. The ground was spring plowed and given ordinary treatment. The flax was sown in drills six inches apart.

Flax has a different system of rooting from that of wheat or oats. Its roots do not go so deep (two and one-half to three feet in this sample), but it makes a much greater fibrous root growth in the upper two feet of the soil. Each plant sends down a single, small taproot, which gives off many small side roots or branches, and these in turn give off numerous fibrous roots or feeders. The upper branches soon curve downward along with the main root which grows rapidly slender and thread-like, until it can scarcely be distinguished from its branches. Diagram No. 2 is an attempt to illustrate the rooting system of this plant.

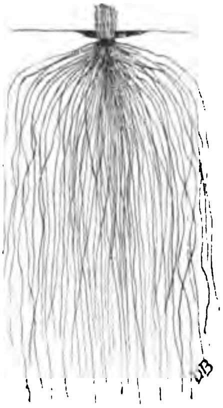


Diagram No. 1.
Wheat Roots.

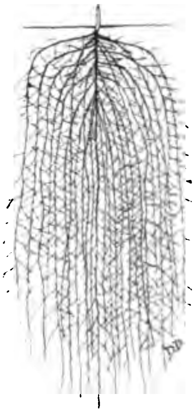


Diagram No. 2.
Flax Roots.

By its intricate system of rooting flax occupies the soil very completely. The crop is not so deep a feeder as wheat or oats, but it is doubtless a much closer feeder, and with drawing the water largely from the upper part of the soil, it is apt to leave the ground in a dry, unfavorable mechanical condition at the close of the season, which sometimes, perhaps, works injury to succeeding crops. Experiments at the Station have shown that on old ground, flax makes a favorable rotation with wheat. Many complain, however, that when flax is sown as a sod crop and followed by wheat, a poor yield of wheat is the rule. This bad result is doubtless due to the physical or mechanical effect which the flax has on the soil. The crop draws the water out of the sod and prevents it from decaying. When this land is backset, the sod turns over in hard, dry, unrotted chunks which will not work up. It is impossible to put such a field into good physical condition for growing wheat or any other crop. The flax crop has in a measure embalmed the sod, and it will not rot now as rapidly as will green sod, so that it may take several seasons for the injurious effects to entirely disappear.

To its close feeding habit, also, we may attribute the subduing effect which flax has upon new land. When a crop of flax gets a good hold on the ground, it tends to starve out other plants.

FIELD PEA ROOTS.

A sample of field pea roots taken eighty-six days after planting, just as the crop was about to be cut for seed shows a spare growth of roots for the amount of foliage which the plant produces. (To get the best sample of roots, peas should be taken when they are green and growing.) The vines in this sample are five and one-half feet long, while the roots only reach a depth of three feet and have a rather scant supply of branches and fibers. The system of rooting is similar to that of flax, but not nearly so extensive. The bulk of the fibrous roots or feeders lie within eight or ten inches of the surface, hence, as practice has shown, peas do not require a deep soil, and a heavy compact soil is not favorable to their growth; a light mellow loam suits them best, and even very sandy, poor land will produce good crops.

BROMUS INERMIS ROOTS.

In Fig. 4 are shown three samples of Austrian brome grass, *Bromus inermis* roots. The samples were taken July 18th and 19th, 1899. Sample No. 1 is one year old from the seed. That is, the seed was sown in the spring of 1898 without a nurse crop. Sample No. 2 is two years old from the seed and sample No. 3 is old sod, five years old from the seed. The samples offer a valuable study both in the growth of the roots and grass. It will be noticed at once that this grass is a wonderful sod producer and a very deep feeder.

It ought to be a good dry weather grass. At one year old the roots have reached a depth of over four feet and have formed a very good sod. The roots of the two-year-old grass were taken to the depth of five and one-half feet as shown in the figure, and I should judge that they went at least a foot deeper. At this age the grass had formed a dense sod six to eight inches thick and the whole soil to the depth shown was fully occupied by its roots. The sample of old grass was from a field which was a little lower and perhaps not quite so well drained as the field from which the other samples were taken. This may account for its less length of roots. What the roots lack in length, however, they make up in numbers. Such a network as this sample shows is the wonder of all who see it. The sod is ten to twelve inches thick and so dense in the first six inches that great difficulty was experienced in washing out the dirt; in fact, there are more roots than soil at this depth. The system of rooting is similar to that of wheat already described. The grains and grasses are much alike in this respect.

In studying the growth of this grass, we notice that as the soil becomes filled with its roots there is less and less growth of foliage. The same fact is more or less characteristic of all perennial grasses. Year after year, the grass keeps sending down new roots, while the old ones continue to live and grow. The old and new roots were easily distinguished in the two-year-old sample when it was first taken, the new roots being white and tender, while the old ones were more woody and darker in color. At the stage when sample No. 3 was taken, much of the available plant food in the soil has been stored up in the roots of the grass. When this sod is broken up and the grass killed, these roots gradually decay and enrich the soil for future crops.

NATIVE PRAIRIE GRASS ROOTS, TIMOTHY ROOTS AND THE ROOT GROWTH OF GRASSES COMPARED.

In Fig. 5 are shown three samples of grass roots taken from old meadows. On the right of the figure is a sample of timothy roots five years old from the seed; on the left is the sample of Austrian brome grass roots five years old from the seed, already described, and in the middle, a sample of native prairie grass roots taken from a field which has never been broken. This sample is mostly native red top and wild wheat grass, *(Agropyron tenerum Canadensis)*. This is the wild prairie grass as it is today, after the prairie has been a hay meadow for twelve or fifteen years. This sample was as good as any I could find in a forty-acre field.

As will be seen the native prairie grass does not make much of a sod when compared with the brome grass. Some of the roots reach a depth of four feet, but they are not nearly so numerous as are those of the brome grass. Even the timothy makes a thicker and denser sod (four to six inches) than does the prairie grass, although its roots do not go so deep, reaching a depth in this sample of less than three feet. On the other hand, the roots of brome grass, as shown in Fig. 4, extend more than five feet deep.

When the wild prairie is first broken, the soil is mellow, moist and rich, producing abundant crops. After a few years of continuous cropping and cultivation, the physical condition of the soil changes; the soil grains become finer; the soil becomes more compact and heavier to handle; it dries out quicker than it used to; bakes worse, and often turns over in hard clods and lumps when plowed. This compact texture and bad mechanical condition of the soil make it difficult for the young roots of plants to develop properly, causing, at the same time, an insufficient supply of air in the soil, which is almost, if not equally as detrimental to the crop as an insufficient supply of soil water. After a soil has been cultivated and cropped a long time, it tends to run together and is very sticky when wet, but when dry the adhesive character disappears almost entirely. The grass roots which formerly held it together are decayed and gone, and now when loosened by the plow, it is easily drifted and blown away.

The perfect tilth and freedom from clods so characteristic of virgins soils is always more or less completely restored whenever land has been laid down to grass for a sufficient length of time. After the ground is covered with sod, the puddling action of rain is prevented. As the roots grow, the soil particles are wedged apart in some places, and crowded together in others, and by means of lime or other materials, the small soil grains become cemented into large ones, and thus the open and mellow character of virgin soil is restored—and not only this, but by the accumulation of plant food in the roots, the soil is made more fertile for succeeding crops.

In rotation experiments at this Station, four crops of wheat after two crops of timothy, have yielded as an average, nearly six bushels more wheat per acre than was obtained from adjacent land cropped with wheat continuously, giving better results than were obtained by rotating with cultivated crops. Laying land down to grass is nature's way of renewing the soil, and from the above study, I conclude that nature will respond well to Bromus inermis in North Dakota.

POTATO ROOTS.

Fig. 6 is a sample of potato roots (variety, Early Ohio) taken July 5th, 1899, forty-three days after planting, just as the plants were coming into blossom, and about the time the crop was receiving its third cultivation. The sample shows the root growth between two hills, growing in adjacent rows. The hills are three feet apart.

The ground from which the sample was taken has grown wheat for several years, and was spring plowed. Each hill is the product of a medium-sized whole potato planted about five inches deep.

The roots washed out well. There did not seem to be much growth of fibrous roots at this time, only the skeleton system shown in the cut, supplied with numerous short delicate root hairs. Wheat stubble turned under when the ground was plowed in the spring shows in the picture. The seed appears prominent, still apparently sound and whole. Close examination, however, showed it to be little more than a shell. Only a few of the eyes on the upper side of each seed potato have produced shoots, the rest remaining dormant or partially so. The hill at the right contains only three stalks which spring from two separate eyes. This is an illustration that a large number of eyes are not necessarily detrimental in that they produce too much vines. Twenty-five little potatoes, by actual count, had set on this hill—the largest ones were about the size of large peas. The hill at the left contains seven stalks, which grew from five eyes. This plant has also more numerous but smaller roots than the other.

The main part of the root growth at this stage lies within eight inches of the surface of the ground. A few roots reached a depth of eighteen inches, but like the young corn, the greatest root growth has been made in a horizontal direction. The roots from each hill already meet and interlace. Some have attained a length of over two feet. At six inches from the hill some of the main laterals are only two and one-fourth inches from the surface of the ground, while midway between the rows their depth is barely three inches.

Other points noticed in this study are that the new potatoes form above the old seed potato, also that the roots start out above the seed. (These statements are true in general. If the under eyes of the seed produce shoots, roots and tubers may develop just below and at the side of the seed.) The depth of planting therefore determines largely the depth at which the new potatoes are produced and to some extent, the depth of the horizontal roots.

EFFECT OF DEEP AND SHALLOW CULTIVATION ON POTATO ROOTS...

Figures 7 and 8 are root samples of Early Ohio potatoes taken August 3rd and 4th, seventy-two days after planting. The vines were green and growing at this date, but the tubers had reached nearly full size. These samples constitute a study of the effect of deep and shallow cultivation on the roots. The main root growth at this stage, as shown by the shallow cultivated sample, Fig. 7. is mostly in the first foot. Several of the large horizontal roots are within three inches of the surface at a point midway between the hills (the hills were three feet apart), and one large root was caught on the wires one inch from the surface. Some of the vertical roots reached a depth of two and one-half feet. The deep-growing roots were very tender and brittle and easily broken off in washing. The horizontal roots send down many vertical branches which in this case often reached a depth of two feet. These were quite slender and few of them were saved. Their stub ends will be noticed in the cut. In the sample taken earlier (See Fig. 6), the stalks or stems were all attached to the seed, but the growing tubers have separated them, until in this sample they are sometimes as much as four inches apart. The original seed potato has entirely disappeared. Since the roots are fast to the stem they must be stretched or dragged through the earth to some extent, and occasionally one was found broken off.

The two samples are an object lesson to the careful observer. It becomes evident at once as we compare them that the deep cultivation and hilling has destroyed many roots. Many experiments have proven that the potato is injured by deep cultivation, but these samples of roots taken from adjacent plots cultivated shallow and deep respectively, show to the eye the reason why.

In order not to injure the roots, the shallow culture plot was hand-hoed and received no hilling. The deep culture plot was cultivated moderately deep with a five-tooth, single, horse cultivator. The hiller was run no deeper than was necessary to do a good job of hilling.

Nearly all the long horizontal roots which appear in the sample cultivated shallow were destroyed by the deep cultivation and hilling; moreover, the numerous vertical roots which proceed from the horizontal roots downward into the soil with all their intricate system of fibers and root hairs by which the potato receives its food, have been dissevered and destroyed by this method of culture.

In the hilled sample, midway between the rows, the roots nearest the surface of the ground lie at a depth of seven inches, while in the sample receiving shallow cultivation the bulk of the horizontal roots are within seven inches of the surface. The hilling, by throwing the earth up over the hill raises the surface at this point and places the tubers apparently deeper in the ground. This is practically the only advantage claimed for hilling.* In very heavy soils it often seems necessary to plant potatoes shallow and then hill them in order to cover the tubers and give them mellow ground in which to grow and expand, but in most soils, and especially those favorable to potato culture, better crops are secured by deep plowing, deep planting and shallow, flat cultivation.

Our Station farm land is not good potato soil, being too heavy and gummy. Experiments conducted for two years, 1898 and 1899, have given the following results:

	Yield per acre, bu.
Potatoes cultivated shallow not hilled	149
Potatoes cultivated deep and hilled	132
Difference in favor of shallow culture	17
Potatoes planted three inches deep	153
Potatoes planted four inches deep	160
Potatoes plaeted five inches deep	140
Potatoes planted six inches deep	148

In the first experiment the potatoes were planted about four inches deep. In the last trial all plots were given medium shallow, flat cultivation. The hilled, and deeper planted potatoes are better in quality and are subject to less loss by scab and sun-scald than the others.

A sample of Early Ohio potatoes taken ninety days after planting, when the vines were beginning to die and the tubers were nearly ripe, showed a depth of roots of over two and one-half feet. The main lateral roots turning downward have reached depths almost equal to those of the vertical roots beneath the hill, sending out, meanwhile, small hair-like branches, which extend outward and downward, so that the soil at this time was fairly well filled with roots to the depth of two and one-half feet. The roots were very brittle, nearly all the branches were washed away, and some of the main roots were broken. The system of rooting is, in some respects, similar to that of corn already described, but the early potato is not so great a forager as corn, rooting neither so deep nor so wide, nor occupying the soil so completely with its fibers. For this reason it stands close planting, and does not require so deep a soil as some other crops. But for large yields the crop must have an abundant supply of plant food near the surface and a mellow, open, yet moist soil, kept so by frequent and thorough cultivation.

LATE POTATOES.

Fig. 9 is a root sample of late potatoes (variety, Rural New Yorker No. 2) taken August 20th, 1899, ninety days after planting. The tubers are of fair size but not nearly mature. The vines of this variety were perfectly green when killed by frost a month later. At the stage when this sample was taken, the roots had reached a depth of fully three feet. The horizontal roots interlace between the rows, some extending almost from hill to hill—hills three feet apart. Midway between the rows the main roots are only three inches from the surface.

The roots were very tender and nearly all the branches were broken off in washing. The sample is a very fair illustration of the main root system. All the main roots, both horizontal and vertical, send out in all directions numerous long hair-like branches. These slender branches themselves give rise to finer feeders and root hairs. The late potato roots more freely, more deeply and occupies the ground more completely than the early potato. It requires more root room, and will not stand so close planting as the early sort. When the hills are three feet apart each way, the soil is quite fully ocupied with roots to the depth of three feet, as shown in the sample.

EFFECT OF SUBSOILING ON THE GROWTH OF POTATO ROOTS.

A duplicate of the sample shown in Fig. 10 was taken from subsoiled ground prepared as noted under sugar beets. The difference in the root growth of the two samples was not marked. Subsoiling seems to have caused a greater growth of small roots in the upper part of the soil (the part loosened) but a less growth in depth than the ordinary treatment. The roots of the sample from the ground not subsoiled were larger and longer than those of the other sample.

SUGAR BEET ROOTS.

Fig. 10 is a sample of sugar beet roots taken July 14th, 1899, fifty-two days after planting. The beets were sown in drills two feet apart; they had been cultivated three times and were thinned to about six to eight inches apart in the row. The ground from which the samples were taken has grown wheat for several years and was spring plowed about six inches deep. The sample is a section of a row, four feet in length.

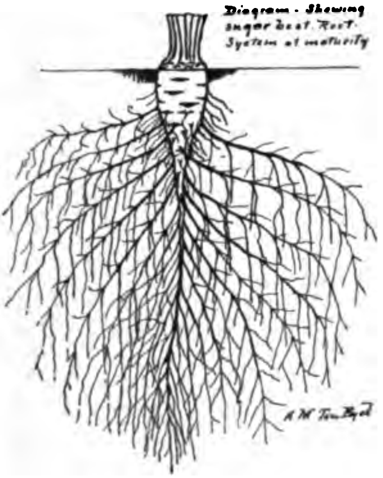
The roots were very tender. Nearly all the branches were washed off. Counting from the right, the main taproots of plants Nos. 2 and 3 were broken. Plants Nos. 4 and 5 had divided roots, while Nos. 1 and 6 had straight taproots which were washed out to nearly their full length, over two feet, as shown. The branches at this stage of growth extend out almost perpendicularly from the main taproot. They were not numerous, only four to eight inches long and white and slender with enlarged ends. There were no branches except a few fuzzy, short ones within four inches of the surface of the ground. Up to this stage sugar beets may be cultivated deep without injury to the roots. While corn and potatoes make a large lateral growth of roots near the surface early in the season, the root of the sugar beet grows directly downward, making very little lateral growth. The very nature of the root growth of these several plants indicates the method of cultivation which each crop should receive.

A sample of sugar beet roots taken eighty-eight days after planting, when the beets had reached nearly their full growth, showed a depth of roots of over three and one-half feet. The roots were still very tender and brittle, and most of the branches were broken. Many of the lateral roots extended outward two feet or more at this time. A number of small, short fibrous roots have appeared near the surface, still too short, however, to receive much injury from the cultivator. The first long horizontal roots start from the beet four inches from the surface. Midway between the rows they have reached a depth of five to six inches. The greatest amount of branching and fibrous growth takes place in that space between eight inches and fourteen inches in depth. All the upper and horizontal roots send down numerous hair-like branches which often reach two to three feet in depth. These branches are much like those on the potato roots already mentioned and were very tender and difficult to save.

Figures 11 and 12 are samples of sugar beet roots taken October 12th. The samples constitute part of a study on the effect of subsoiling on the root growth and development of the sugar beet. At this date the beets were fully mature, the tops were partly dead and the roots seemed on the point of decaying. Only the larger roots were secured, and these were often broken. The roots did not seem to extend much deeper into the soil at this time than they did in the sample taken in August, but the fibrous growth in the surface six inches was much greater than it was in the former sample. These surface roots were not preserved in the samples, but it was noted that they occupied the soil six to eight inches each side of the beet. It seems probable that the sugar beet may feed quite extensively in the surface soil late in the season, after cultivation is discontinued. The fact remains, however, that the vegetable is by nature a deep feeder. The main root development is deep in the ground, and not until late in the season do roots develop near enough to the surface to be injured by the cultivator.

The root system of the sugar beet differs from that of any of the other plants studied. The vegetable itself is really the enlarged upper part of the taproot which extends almost perpendicularly downward into the ground, becoming rapidly smaller in diameter in the upper part of its course, the lower part being quite small and thread-like, and reaching, in several samples, a depth of over three and one-half feet. From this central root, branches spread outward and downward into the soil on all sides. The upper main branches are the largest and extend outward almost horizontally for more than two feet. Those deeper down incline more and more until the last branches run nearly parallel to the taproot. The diagram merely represents the skeleton of the root system.

Sugar beet roots are so tender and brittle that I have been unable, in six trials at different stages of their growth, to secure a sample in which the roots were preserved sufficiently to give a good idea of the root system. The following diagram was made from a study of a sample taken in 1898:



EFFECTS OF SUBSOILING ON THE ROOT GROWTH AND DEVELOPMENT OF SUGAR BEETS.

In this experiment one plot was subsoiled eight inches below the bottom of a six-inch furrow, thus loosening the ground to the depth of fourteen inches. The other plot was simply plowed six inches deep. The samples shown in Figures 11 and 12 are fair representatives of the types of beets which grew on the respective plots. Each sample is a cross section showing beets on adjacent rows.

The main apparent difference between the two samples is in the shape of beets. The beets on the ground not subsoiled are short and ill formed and grow above the ground. The chemist tells us that for the best production of sugar the beets must grow well beneath the surface of the soil and be long and tapering. This form and condition are shown in the sample from the subsoiled ground. Aside from the difference in the form of the beets themselves, there is considerable difference in the rooting systems. The roots of the beets from the subsoiled ground, compared with the others, are found to extend deeper into the soil and to make a more extensive and greater fibrous growth in that portion of the soil loosened by subsoiling. The irregular form of the beets on the ground not subsoiled causes an irregular root development; divided taproots often occur, resulting in a less depth of root. This study shows that the sugar beet needs deep, well loosened soil, not only that it may have room to grow and expand, but also that the roots may properly develop and secure the necessary plant food.

By actual count 71 per cent. of the beets from the ground not subsoiled were classed as ill formed, while only 40 per cent. were so classed from the subsoiled plot. The total yield was about the same from each plot.

	Subsoiled plot.	Not subsoiled plot.
Average weight of beets	1½ lbs.	2 lbs.
Loss of weight in trimming	29 per cent	34 per cent.
Percentage of sugar	11 4 per cent	11 2 per cent.
Percentage of purity	75½ per cent	78⅛ per cent.

There seems to be no marked difference in the sugar content of the two samples as reported by Professor Ladd, Station Chemist. All sugar beets grown at this Station have tested low in sugar.

THE SOIL IN WHICH THE ROOTS GREW. *

The soil of the Station farm is fairly typical of the famous Red River Valley wheat lands, and, in a general way, it may be described as very fertile, deep, black loam, underlaid by a subsoil slightly finer in texture and lighter in color, often called a clay, but which is more properly a compact, heavy loam. The whole soil is a water deposit formed by the gradual filling and draining of old Lake Agassiz.

The soil is sticky and heavy to handle when at all wet and below the depth to which it is loosened by the plow it is generally compact and gummy. Spots of real gumbo are frequently met with. The soil contains a large amount of organic matter, ten to twelve per cent in the surface foot, and has a very large water capacity, samples of the surface foot as taken from the field (not saturated) often showing over forty per cent of soil moisture, and it is uncommon to find less than twenty per cent of moisture in the upper three feet of the soil, even in a dry time.

GENERAL REMARKS.

Crops may be divided into two classes, those planted in rows and cultivated, and those sown broadcast or in drills a few inches apart and not cultivated. The roots of the plants which constitute the last class named penetrate deepest into the soil but make only a short and rudimentary lateral growth; while the roots of the cultivated crops spread out horzontally in every direction and

* (See bulletin No. 36 for complete description and mechanical analysis.)

occupy more soil, but do not extend so deep into the ground as do those of the sowed crops. This may be the result of the different methods of culture. Or, more correctly, perhaps, the different methods of culture are the result of the different systems of rooting which are characteristic of the various plants.

It is evident from the samples studied that there is much difference between plants in regard to the growth and development of their roots. The rooting systems of the cereal grains, so far as examined, are similar, and yet, on close study, they are found to differ much in depth of rooting, amount of branching, color and size of roots, etc. The root development of grasses is similar to that of grains, but the systems are more intricate, the roots are far more numerous, and differ much in quality and structure from those of the grains, in being tough and woody. Even grasses differ much from each other in regard to extent and depth of rooting. Experience has taught us that timothy is not a good dry weather grass, and that Bromus inermis is, and samples of the roots show us why this is so, when we see the great difference between them in depth of rooting.

There is even greater difference between the roots and root development of the several plants cultivated in rows. Corn and potatos, although alike in that they both have a large lateral growth of roots near the surface, differ greatly in their systems of rooting, and in the character of their roots. Corn roots are fairly tough and do not break badly in washing, while potato roots are quite brittle and decay very quickly when the vines die. Sugar beet roots are more tender yet than potato roots, and the system of rooting is scarcely comparable to either of the others. The study of the roots of these plants indicates the kind of cultivation each crop should receive, and makes clear to us why it is necessary to plant and cultivate certain crops in certain ways in order to get the best results.

In the discussion of potato roots, attention was called to the fact that the depth of planting determines the depth of the lateral or side roots and also the depth at which the new potatoes are formed. This statement is true to a large extent of almost any crop, in that the depth of the main lateral roots depends largely on the depth at which the seed is planted. Thus, wheat planted shallow will produce its side roots near the surface, and although the grain may, under favorable conditions of weather and soil, start well, yet a dry spell at any time before the wheat is mature may injure the crop more than it would wheat sown deeper. For the best results, seed must be planted deeper in light soils and in dry climates than it is in heavy soils and regions of plentiful rainfall. This rule can be laid down for many crops: If you want to have the roots well under the ground, plant the seed at a good depth.

When we consider the depth to which the roots of many crops penetrate, we must conclude that a crop is injured by a drouth not through an insufficient supply of water so much as through a lack of other elements of plant food. The fact that the subsoil, when brought to the surface, will not produce crops for the first year or two, is evidence that the plant food and proper conditions for the growth of plants exist only in the surface soil. The plant takes its food dissolved in water, through its roots, from the soil. When the surface soil becomes dry, the plant cannot get enough water solution from this part of the soil to furnish the necessary supply of food material. Hence the crop actually starves for want of plant food and is dwarfed in growth.

Plant study in the past has been mainly above ground. Corn, potatoes, etc., are planted in rows and hills, so that the plants may have room to get the air and sunlight, and be properly cultivated, but when we go beneath the surface and look at the roots of plants, we find other reasons for the success of those systems of cultivation which we practice because experience has taught us they are the best. Not only do plants need room above ground to get the air and sunlight, but their roots require even more room in the soil beneath, that they may properly develop and supply the water and nourishment necessary to the life and growth of the plant.

The study of the growth and development of the root systems of plants offers a wide and profitable field for investigation. The work done by Hays, King and others on the roots of corn has revolutionized the methods of cultivating this crop, and careful study may discover many valuable facts which may lead to better and more successful methods of culture than those at present practiced.

A. M. TEN EYCK.

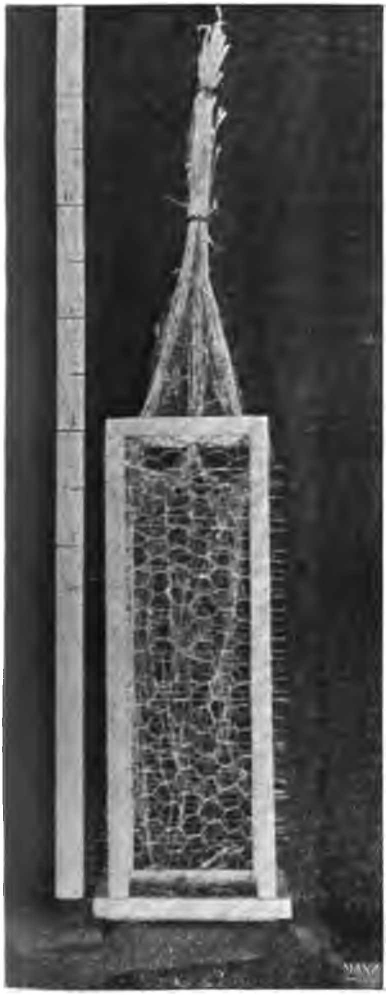


Figure 1—A sample of wheat roots taken at maturity, 110 days after planting.

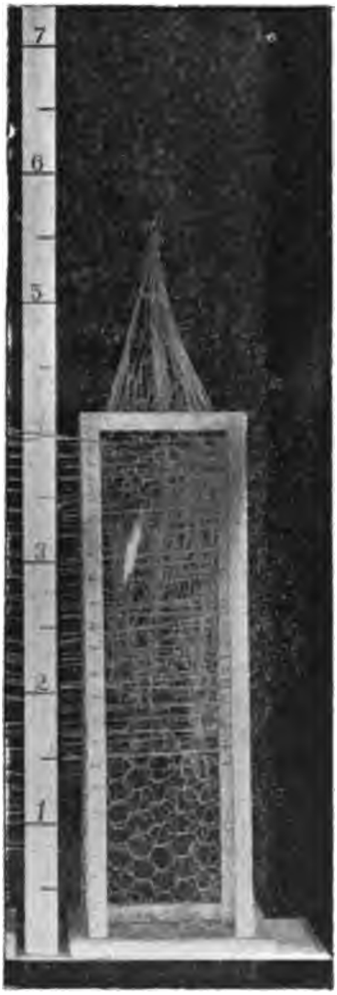


Figure 2—A sample of flax root taken just as the flax was ready to cut for seed, 87 days after planting.

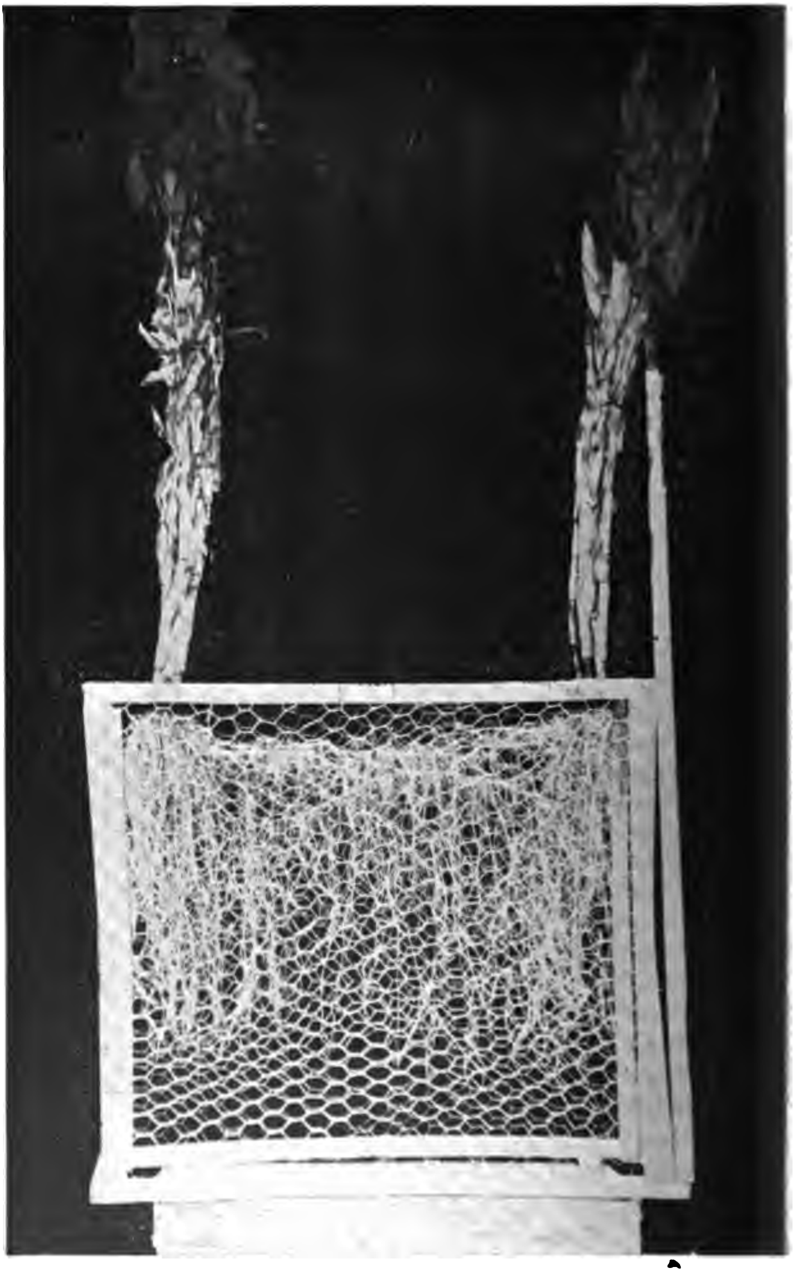


FIGURE 3—Showing the distribution of corn roots between two rows at the end of the growing season. The corn was killed by frost 90 days after planting

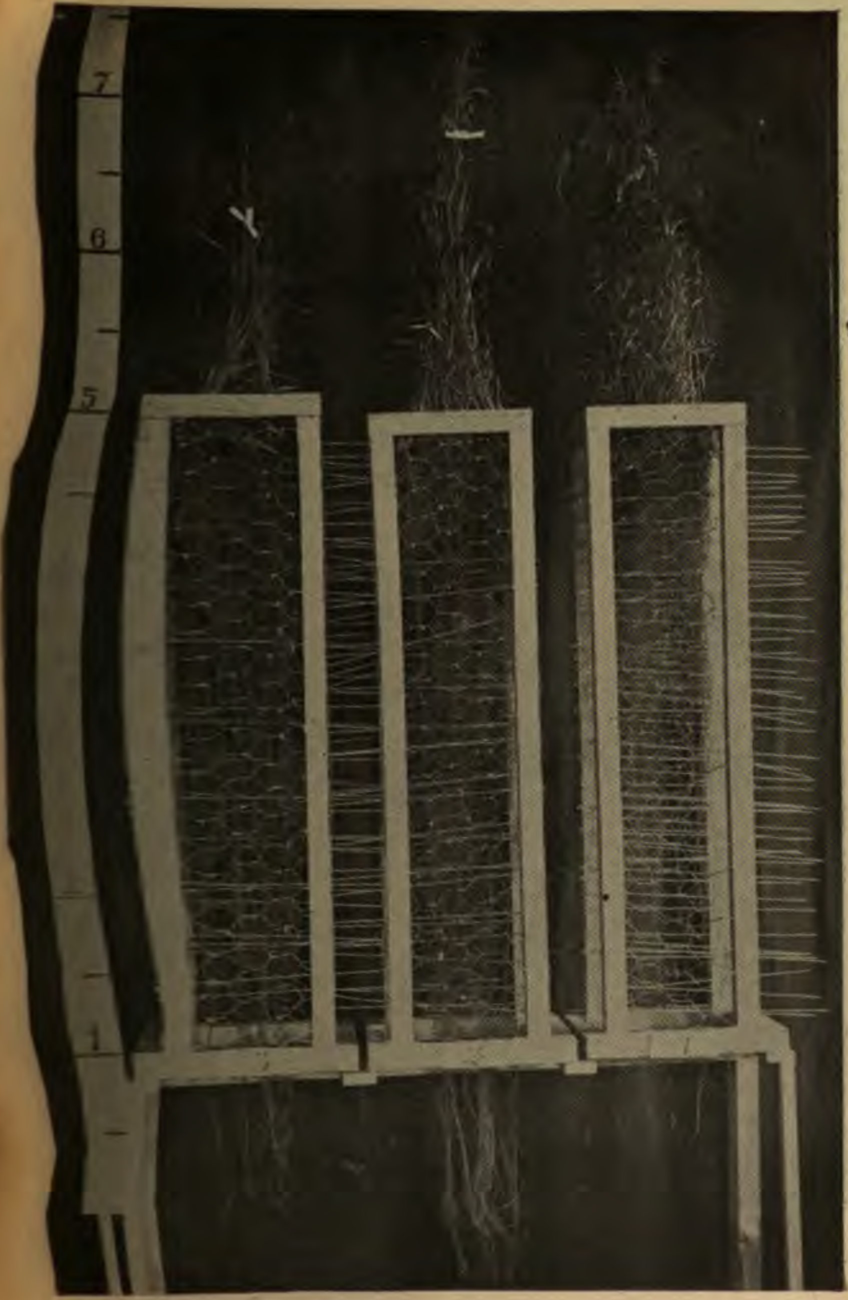


FIGURE 4—Samples of Austrian brome grass (*Bromis inermis*) roots. No. 1—One year old from the seed. No. 2—Two years old from the seed. No. 3—Five years old from the seed, old sod.

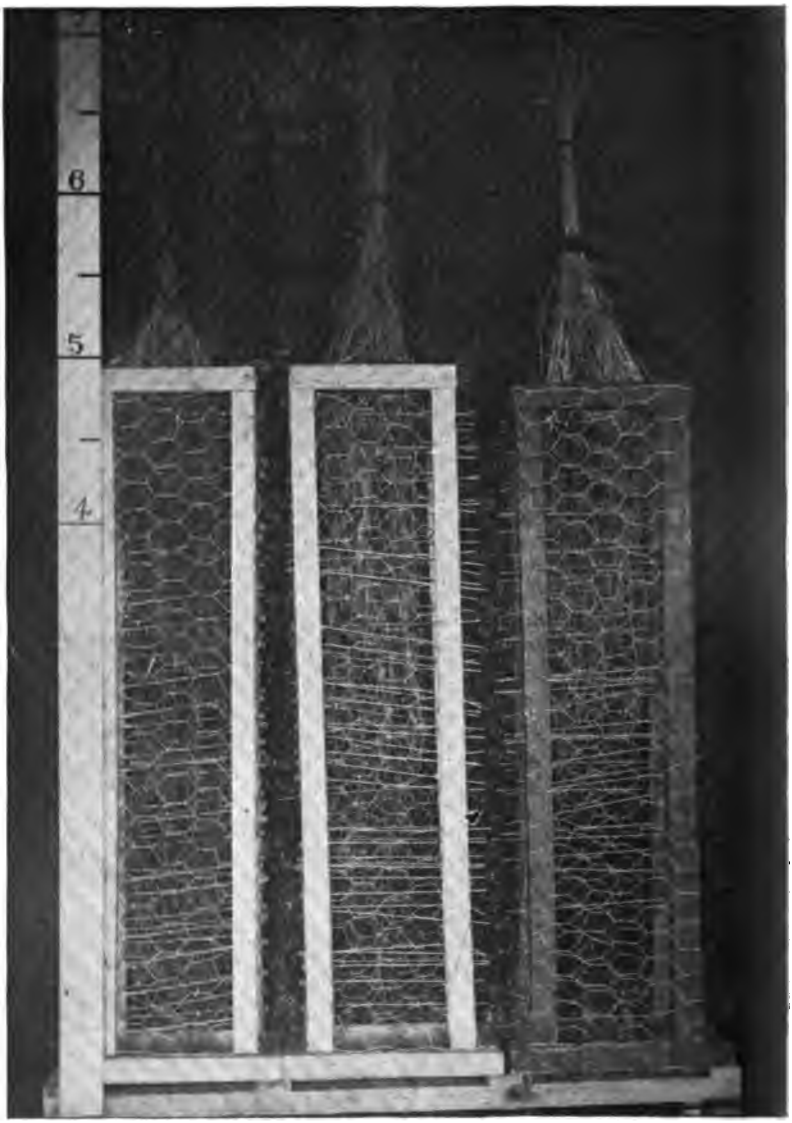


FIGURE 5—Grass roots from old meadows. Sample at the left Bromis inermis; at the right, timothy; in the middle, native prairie grass.

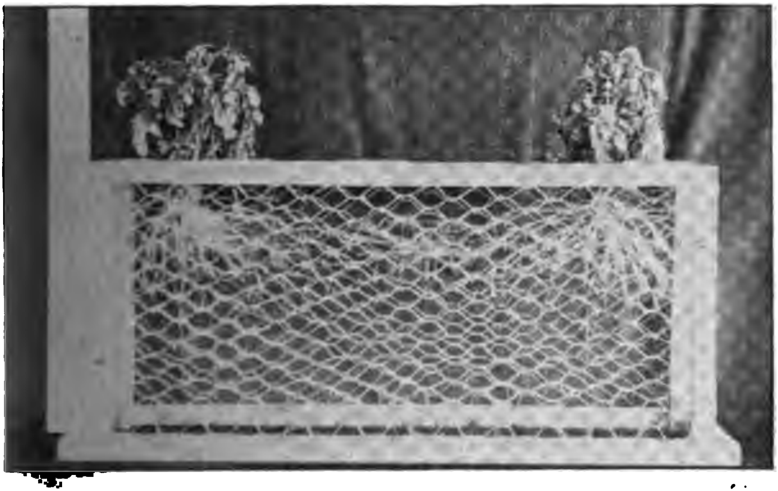


FIGURE 6—A sample of potato roots taken 43 days after planting, just as the vines were coming into blossom and the tubers were beginning to form.

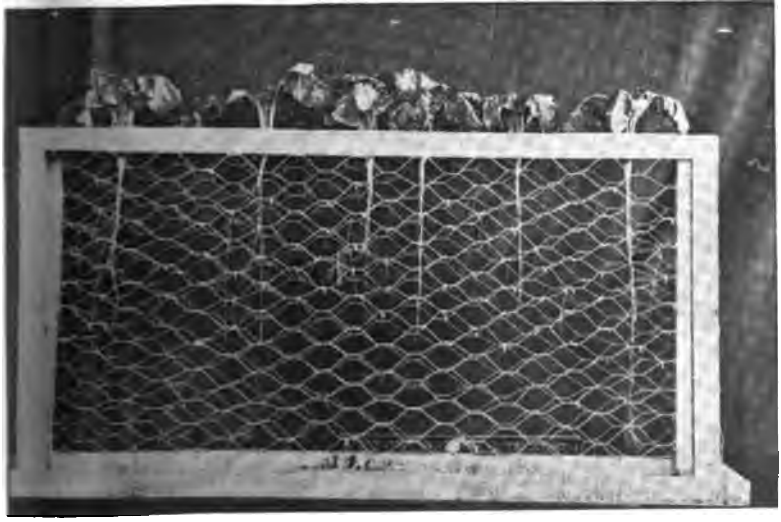


FIGURE 10—A sample of sugar beet roots taken 52 days after planting.

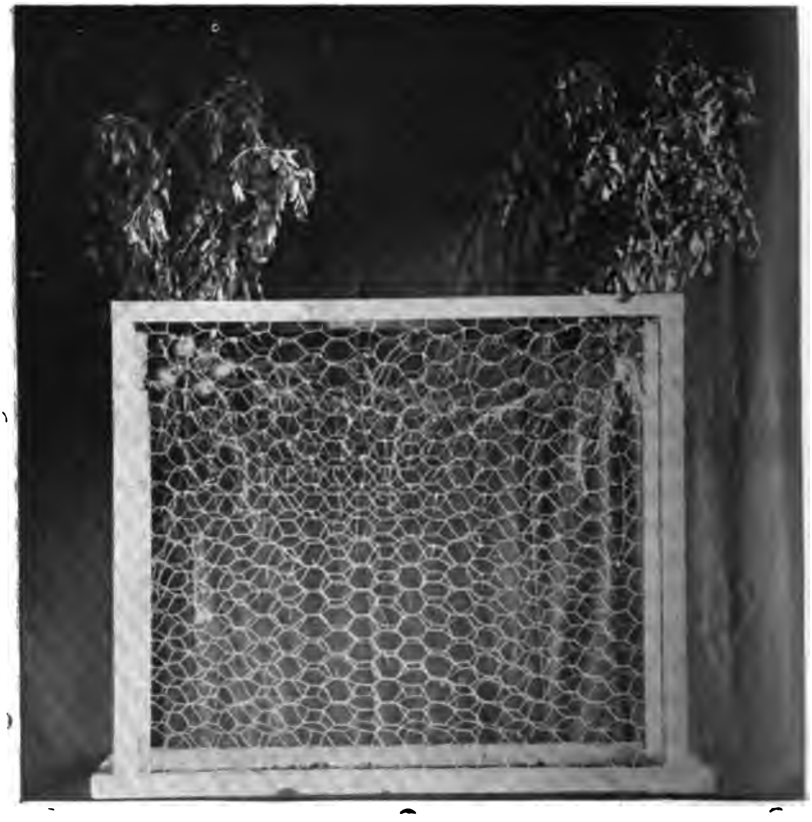


Figure 7—A sample of Early Ohio potato roots taken 72 days after planting, showing the distribution of roots between hills on adjacent rows. The crop received shallow, flat cultivation.

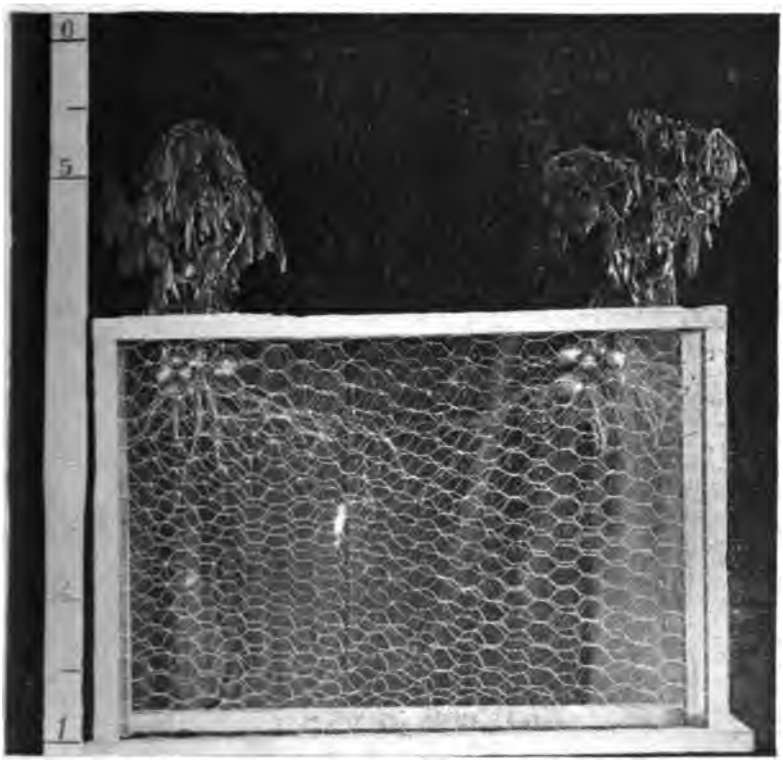


FIGURE 8—A sample of Early Ohio potato roots taken same as sample shown in Figure 7 except that the potatoes were cultivated deep and hilled.

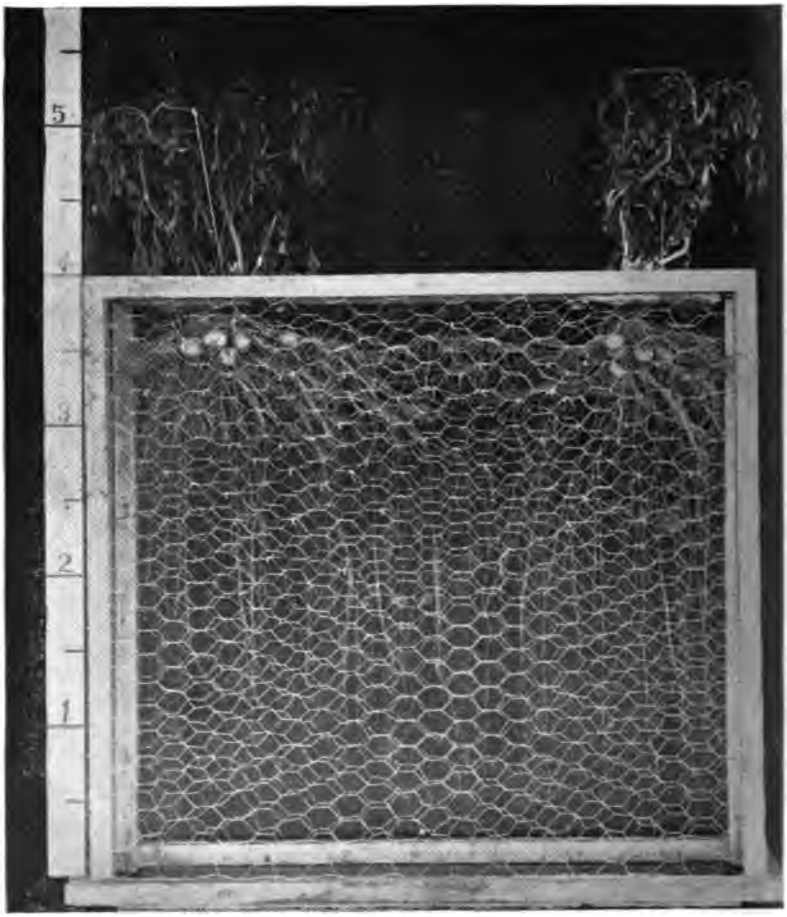


FIGURE 9--A sample of late potato roots showing distribution of roots between two hills on adjacent rows, taken 90 days after planting.

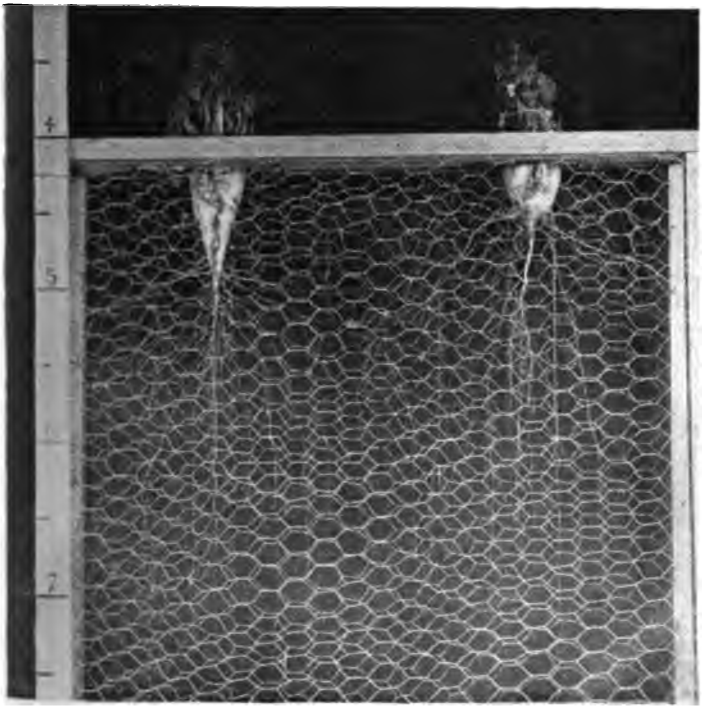


FIGURE 11—A sample of sugar beet roots taken at maturity—grown on ground plowed six inches deep, but not subsoiled.

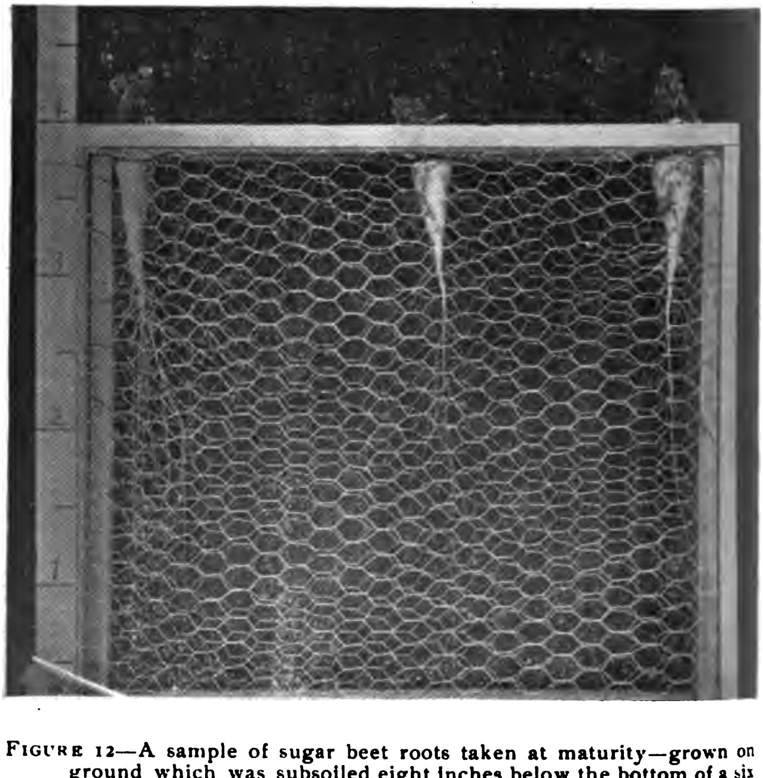


FIGURE 12—A sample of sugar beet roots taken at maturity—grown on ground which was subsoiled eight inches below the bottom of a six inch furrow; i. e., soil loosened to the depth of fourteen inches.

NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 44.

(Revised from No. 35.)

1. WATER HEMLOCK POISONING.
2. PRESERVING EGGS.

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Fargo, North Dakota, U. S. A
June, 1900.

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Water Hemlock Poisoning.

INTRODUCTORY REMARKS.

The exceptionally dry year resulting in shortage of pasturage has caused animals to graze the "sloughs" and low marshy places more closely than in former years. In these "sloughs" and wet places are found quite generally one of the most poisonous plants in this country—namely water hemlock. There have already been reported many cases of animals having died manifesting symptoms of having been poisoned and there is little doubt but what, in some cases, at least, death resulted from eating this poisonous plant or from tramping in the low wet places, crushing the roots and then drinking of the water containing the poison.

We have an unmistakable case near Casselton during the present month where two cows died suddenly, manifesting all the symptoms of having been poisoned. An examination of the blood and contents of the stomach showed the presence of the poison from water hemlock. There have already been reported to us cases of several horses and other animals where the description indicated that death resulted from water hemlock poisoning although no examination was made. Other cases are now being investigated and it seems well to again call attention to the danger from water hemlock being gathered in the hay. In the falls we have had the most general complaints of animals having been poisoned when they are first fed upon "slough" hay.

Meadows and "sloughs" will be cut closer this season than usual and unless precautions are taken to avoid the spots where these plants grow or to first pull and remove these plants before cutting the grass we may expect serious results when we come to feed the hay in the fall. It seems that cattle, horses and sheep alike may be poisoned by eating the hay, the green plant or from drinking the water where the roots of water hemlock are being tramped upon.

Bulletin number 35 having become exhausted we republish the following:

A CASE OF POISONING—WATER HEMLOCK.

On October 22nd, 1898, there were received at the Station from Ellendale, N. D., the stomach and contents of a bull, accompanied by a letter stating that the animal died on the 15th inst. "He was in perfect health until the morning of the 4th about 7 a. m., when turned out for exercise he seemed dumpish and refused to drink." The animal died about 1 a. m. on the 15th. The proprietor further writes, "I lost a bull September 19th, 1897, at same place in a similar manner and am very anxious to ascertain the cause."

The stomach and its contents were subjected to chemical examination and reactions were found for the poison conin. The reactions were characteristic including the peculiar mousy odor emitted when treated with sodium hydroxide. The poison conin is one of the active principles contained in spotted hemlock *(Conin maculatum)* an unbelliferous plant. There is also, found in the water hemlock *(Cicatu maculatum)* a poison similar if not identical with conin of the spotted hemlock, also a resinous substance cicutoxine which is even more poisonous than conin.

Water hemlock grows abundantly in the low ground, on the border of "sloughs" and in the low marshy places in North Dakota. Since much of this "slough" grass is cut for hay it is probable that the water hemlock or false parsley may find its way into the "slough" hay so largely used as a winter feed in Dakota. Finley Dun * says, "It causes weak and staggering gait, the hind extremities being first affected. * *, * * * * * * Dr. John Harley gave a two-year-old thoroughbred colt sixteen ounces of succus conii, corresponding to a pound of fresh leaves and produced in twenty-five minutes dullness and stupidity, drooping and swelling eyelids, but no change in the pulse or pupils. A few minutes later the colt went down upon his knees, appeared to require special effort to keep himself upon his legs, stumbled and walked slowly when led, but in two hours the symptoms had entirely disappeared. Moisond poisoned a horse with half a pound of the dried leaves given as a decoction and observed nausea, spasmodic twitching of the muscles of the extremities, cold sweats, dilation of the pupils, and dullness. * * *

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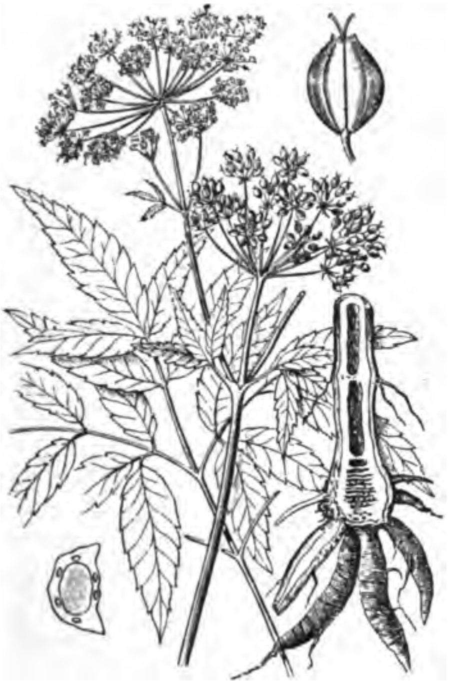
* Veterinary Medicine. Page 405.

Cattle, poisoned, lie as if lifeless, with slow feble pulse, cold extremities, and dilated pupils. Sheep become giddy, listless and sometimes die."

On reporting the probable cause of the death of the bull to the proprietor and requesting that a careful examination be made of the hay for any specimens of the water hemlock there were



—American water hemlock (*Cicuta maculata*).

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* I am indebted to Mr. V. K. Chestnut of the Division of Botany, Department of Agriculture, Washington, D. C., for permission to use the above cut. I also in part reproduce his description of the plant

found fine large specimens of the plant in the "slough" hay being fed. In sending the specimen and commenting upon it he says, "our hay is full of it."

This would seem to settle the question as to the cause of the animal's death, it being produced as a result of eating hay containing water hemlock. Almost every fall during the months of September and October we have had reports of horses or cattle being poisoned, but the conditions have never been favorable for determining the probable cause,, but in this instance it seemed possible to gather full information regarding the facts and to correctly locate the source of the poison. Occasionally there have been reported cases of poisoning when the animals were in pasture, and it is quite likely that in the dry season while feeding on the low grounds that they may have eaten of this plant. Most cases, however, have been from animals eating hay soon after the "slough" hay has been cut. The plant itself is said to lose much of its poisoning qualities when kept for some time in the dry condition. The seeds and roots, however, retain the poisonous principle for a long time. At the time of cutting "slough" hay water hemlock would be in seed and when kept in hay some time before being fed the seeds would quite largely fall out and would not be so likely to be eaten by the animals as when first cut. This would be the reason why animals are so rarely poisoned during the winter months. Animals fed in the yards would not be so likely to be poisoned as barn-fed animals, since the ripe seed would fall out upon the ground and before eaten by the animals, while in the stall much more of the seed would be eaten.

Since cases of poisoning of animals from eating water hemlock and allied plants are by no means uncommon and many cases of poisoning have occurred in this state that were in all probability due to this same cause it is a matter of importance that farmers and stockmen become familiar with the plant. To assist in the better identification of the plant I give a cut of water hemlock, also a description of the same.

"The American species of water hemlock *(Cicuta maculate)* is by far the most virulent plant native in the United States. It is found growing at low elevations, along streams and ponds, and in marshy ground throughout the eastern portion of the continent, extending apparently not very far west of the great lakes. It is perennial in duration and grows to a height of from 4 to 8 feet. In some river marshes it is so extremely abundant that in early summer the landscape is whitened by its bloom. It belongs to the well known parsley family, and may easily be distinguished by its fascicled, spindler-shaped, roots, which are from one and a half to three inches in length, and by the trellised structure of the underground portion of its main stem. Both of these parts are strongly impregnated with a yellow, aromatic, oily fluid, which has an odor resembling that of the parsnip. A few of the common names by which the plant is known in various localities are, water hemlock, wild hemlock, beaver poison, misquash root, muskrat weed, cowbane, and children's bane. It is frequently mentioned in the newspapers under the erroneous name of wild parsnip.

No estimate can be made of the amount of damage done to live stock by these various species, but it is not insignificant. The human victims of the American water hemlock probably average a considerable number per annum. In the State of New Jersey alone two quadruple cases of poisoning were reported during the spring of 1896, which resulted in the death of two individuals. Flack, a German authority, reports a 45 per cent. fatality in thirty-one cases of water hemlock poisoning occurring in Europe.

The symptoms of poisoning are vomiting, colicky pains, staggering, unconsciousness, gnashing of the teeth, and frightful epileptiform fits, ending in death. As no chemical antidote is known, the treatment must consist in a thoroughly cleansing of the alimentary canal and in combating the symptoms as they arise by the use of chloroform, chloral, and such agents as seem to be indicated at the time. Herbivorous animals which have swallowed a sufficient dose generally die, but they are sometimes saved by two or three doses of melted lard, which tends to retard the absorption of the poison in the stomach, and also facilitate its expulsion through the intestines."

Not only are animals poisoned by eating of the plant but many cases are on record where persons have been poisoned from mistaking young plants for parsley and using the fresh leaves in soup.

Children have been poisoned from eating the plant or its seed. The root is more poisonous than the stalk and has been mistaken for horse-radish. Even drinking the water of marshy ground where the roots may be crushed by tramping of the animals may result in poisoning the cattle. The green seeds are much more poisonous than the ripe fruit. Too much care cannot be exercised in harvesting hay from "sloughs" and low ground where this plant may be found. If specimens of the plant are present one should go through and remove all plants and take them to a place of safety or destroy them before cutting the grass, or if very abundant it would be far safer to leave the "slough" entirely.

APPENDED NOTES.

On the part of many there is a demand for a fuller description of the symptoms and post-mortem appearances and to aid veterinarians who may be interested we append the following compiled data regarding these points. We have used such data as has come directly under our notice for conin, water hemlock *(Cicuta maculata)* and spotted hemlock *(Conium maculatum)* for the active principle seems to be the same or similar, and in the descriptions given no distinction seems to be made.

SYMPTOMS.

Conin acts as a powerful and rapid paralyzant, which begins at the extremities and works upward, the extremities meanwhile becoming cold; (Witthaus) the paralysis finally extends to the muscles of respiration and death results from Apuea. If for any cause death be delayed for some time there may be convulsions, and coma accompanied with salivation and involuntary discharges of the bladder and bowels. (Rese). The motor regions of the spinal cord are but slightly affected, although reflex excitability is moderately reduced. The respiratory centrals of the Medulla is paralyzed by a toxic dose, but conin has no effect on the convalutions of the cerebrum until asphyxia supervenes. (Hoare). As soon as the paralysis becomes general the pulse becomes small, feeble and slow, the pupils dilated, accompanied with swelling of the head. (J. H. Steel). The symptoms are, however, subject to considerable variation. In the case of cattle the symptoms above described are general, and may be accompanied with bloating and much bodily pain. Sheep become giddy, listless and sometimes die. Pigs lie prostrate and are unable to rise, pulse not perceptible, body cold and eyes amaurotic, and when left alone lapse into a comatose, hypnotic state, without exhibiting convulsions and apparently no pain.

POST-MORTEM APPEARANCES.

According to most authorities post-mortem appearances are frequently negative. Generally, however, there are evidences of gastric visitation and sometimes ecchymoses are produced in different organs, and the gastric mucous membrane is somewhat reddened. (Witthaus). The heart and vêna cava are empty but all vessels of the brain are more or less congested, and gorged with liquid blood. The lungs are also gorged with dark colored blood, which as in other parts of the body remains fluid and coagulates very slowly. On exposure to the air it attains its natural color. (Wormley). In the case of hogs the mucous coat of the stomach, particularly its cardiac portion is much congested with similar spots here and there.

Throughout the intestines are distended with gas; and liver, spleen and lungs are distended with dark fluid blood. (Dun). Chestnut mentions bloating as one of the characteristic symptoms from water hemlock poisoning and in the cases which have been reported to us this seems to have been, to the casual observer, one of the most characteristic post-mortem appearances.

Preserving Eggs.

(There continues to be a general call for the method of preserving eggs as published in bulletin number 35, now out of print, so that it is necessary to republish this article in this connection.)

By way of introduction it might be said another year's experience confirmed all that has been said in the original article and furnishes us some further information.

Some of the "water glass" on the market is of a very inferior quality, is strongly alkalin from the presence of free soda or potash and in such the eggs will not keep well. They soon take on a disagreeable odor and flavor. Again some of the "water glass" is very thin and in such cases the proportion used should be somewhat larger. None who have tried the method, following the instructions given report a failure. I quote the following from one letter commenting on the experiment:

"I put down three barrels, nearly three hundred dozen. Barrels numbers one and two were strictly fresh eggs when put down and came out in very good condition at the end of four months. Barrel number three was filled with store eggs, but supposed to be fresh laid eggs and when put under the tester appeared to be all right. They came out with a disagreeable odor, and the liquor was also spoiled, all caused by stale eggs I suppose. This system of preserving eggs could be used on a large scale if it was possible to get perfectly fresh eggs, but our methods of testing is so crude and unreliable that it is impossible to depend upon it."

The general tenor of all reports thus far received agree with the above. By this method of preserving eggs when the water glass is drawn off and water run through, the eggs are left uniformly clean and with no discoloration of the shell.

Many experiments have been made with other means of preserving eggs, but none have proved so uniformly satisfactory. If the eggs are coated with vaseline they will keep for some time, but such eggs are disagreeable for handling.

It was thought that water containing a little formic aldehyde would prove a good preservative, but our trials showed that the chemical penetrated the shell leaving the white of the egg as though hard-boiled, thus rendering the method unfit for use.

PRESERVING EGGS.

(Republished from Bulletin number 35.)

There is needed a simple method for preserving eggs, a method that will enable farmers, poultrymen and even the consumers to put away eggs during the summer months when they are so plentiful and worth only five and ten cents per dozen, and to preserve them until the winter months when it is quite impossible to find a supply of fresh eggs and they command a price of twenty or thirty cents per dozen.

At the present time eggs are largely packed in lime, salt and other products, or are put in cold storage for winter use, but such eggs are very far from being perfect when they come upon the markets, and frequently more than one-half of them are unfit for use, if we are to judge from the condition of the Fargo market. A method to be generally employed must be simple, cheap and the eggs when wanted for use must be of good quality.

During the past summer a statement was made in one of the agricultural journals that water glass was a preservative for eggs. From the nature of this product the method seemed promising, and it was decided to make some experiments to determine whether it had any real value for this purpose. The shell of an egg has a very thin coating of mucilagenous, albuminous matter upon its surface that seems to protect the eggs for a considerable time from atmospheric action or the introduction of the germs of decomposition. If this coating be removed immediately after the egg is deposited, while still warm, the keeping quality seems to be much reduced, or if eggs that become soiled in the nest are washd, this albuminous coating is softened and the life of the egg shortened thereby. This would suggest that a method for preserving eggs should be one based upon experiments that would tend to more thoroughly protect this natural condition of the egg, and at the same time keep the air as far as possible from the eggs. For this purpose lime has not proved wholly successful, neither has salt or brine, for while each of them aid in protecting against air the albuminous coating of the egg has been destroyed and the shell much weakened. These adverse conditions seem to be more largely overcome by the use of water glass than in either of the other methods. After experiments with solutions of various strengths, and under varying conditions, we found that a 10 per cent. solution of water glass would preserve eggs very effectually, so that at the end of three and one-half months eggs that were preserved the first part of August still appear to be perfectly fresh. In most packed eggs, after a little time, the yolk settles to one side, and the egg is then inferior in quality. In boiling eggs preserved for three and one-half months in water glass the yolk retained its normal position in the egg, and in taste they were not to be distinguished from fresh unpacked store eggs. Again, most packed eggs will not beat up well for cake-making or for frosting, while eggs from a solution in water glass seemed quite equal to the average fresh eggs of the market. It should be borne in mind that in these experiments only fresh eggs were used for preserving; no egg was more than four days old. Eggs that have already become stale cannot be successfully preserved by this or any other known method so as to come out fresh.

Water glass (Sodium Silicate) is a very cheap product that can usually be procured at not to exceed 50 cents per gallon, and one gallon would make enough solution to preserve fifty dozen of eggs, so that the cost of material for this method would only be about 1 cent per dozen. Water glass is sodium and potassium silicate, sodium silicate being usually the cheaper. If wooden kegs or barrels are to be used in which to pack the eggs they should first be thoroughly scalded with boiling water to sweeten and purify them. For those who may desire to try this method I give the following:

DIRECTIONS.

Use pure water that has been thoroughly boiled and then cooled. To each ten quarts of water add one quart of water glass. Pack the eggs in the jar and pour the solution over them covering well.

Keep the eggs in a cool dark place. A dry cool cellar is a good place.

If the eggs are kept in too warm a place the silicate is deposited and the eggs not properly protected. Do not wash the eggs before packing for, by so doing, you injure their keeping quality probably be dissolving the mucilagenous coating on the outside of the shell.

For packing use only perfectly fresh eggs, for stale eggs will not be saved and may prove harmful to the others.

All eggs packed contain a little gas and in boiling such eggs they will crack. This may be prevented by making a pin-hole in the blunt end of the egg. To do this hold the egg in the hand, place the point of a pin against the shell of the egg at the blunt end and give the pin a quick, sharp blow, just enough to drive the pin through the shell without further injury to the egg.

E. F. LADD,
Agricultural College, North Dakota.

June, 1900.

The North Dakota Agricultural College

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 45.

FEEDING TRIALS WITH WORK HORSES.

1—ROUGHAGE—
  I. BROME HAY.
  II. TIMOTHY HAY.
  III. OAT STRAW.

2—GRAIN—
  I. OATS.
  II. BARLEY.
  III. MALT.
  IV. CORN.
  V. WHEAT.
  VI. BRAN AND SHORTS.

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Fargo, North Dakota, U. S. A.
September, 1900.

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FEEDING TRIALS WITH WORK HORSES.

BROME GRASS HAY FOR HORSES.

In an experiment to determine the relative value as compared with timothy hay, brome grass hay was fed to horses, oats constituting the grain ration in both cases. The experiment was conducted for a period of forty-two days. This is too short a period from which to draw definite conclusions as to the merits of each; but a limited supply of brome hay made it necessary to thus limit the trial. Two work teams were used for the experiment. One horse from each team was placed upon brome hay for four weeks, at the end of which time it was changed to timothy hay, while its mate received brome hay.

The stock ate the brome hay somewhat cleaner than they did the timothy. They did exactly the same amount and kind of work and were given practically the same quantity of oats. The work done varied from plowing sixty hours a week to idleness, and averaged a little over five hours per working day.

BROME HAY COMPARED WITH TIMOTHY HAY.

	GRAIN lbs.	HAY lbs.	Gain or Loss in wt. lbs.	WORK lbs.
Feeding Oats and Timothy.				
Total, 2 horses, 42 days..........	1,221.00	1,838.50	* 35.00	374.00
Average, 1 horse, 1 day..........	14.50	21.90	* .42	5.20
Feeding Oats and Brome Hay.				
Total, 2 horses, 42 days..........	1,221.00	1,863.50	* 65.00	374.00
Average, 1 horse, 1 day..........	14.50	22.20	* .77	5.20

* Gain.

The experiment showed a little better results from the brome hay, but the weights did not run uniform enough to warrant a positive decision. Other horses at the Station ate threshed brome straw with a relish. This would indicate that the straw is palatable, and that it probably contains considerable nutrition. The large percentage of leaves upon it, and the number of stems which do not head out, add to the palatability and the nutritive value of brome hay.

STRAW FOR HORSES.

Interest in straw as a rough forage is such, this season, that I feel justified in republishing the result of a trial, already published in Bulletin No. 20, made in feeding oat straw to horses.

Eight horses and four mules were used in the trial. Oat straw in good condition was fed as compared with upland prairie hay. Oats was fed to part of the stock during the trial, and bran and shorts, mixed in equal parts by weight, were given to the others.

OAT STRAW COMPARED WITH TIMOTHY HAY.

	Graain Eaten lbs.	STRAW OR HAY		Loss in Weight lbs.	Work Done hrs.
		lbs Eaten	lbs. Refused		
Feeding Straw & Grain.					
Total for 12 animals for 30 days	4,379.00	5,740.00	1,523.00	318.00	852.00
Average 1 head, 1 day..	12.10	15.90	4.20	.89	2.40
Feeding Hay and Grain.					
Total for 12 animals for 30 days	3,495.00	9,323.00	1,791.00	311.00	850.00
Average 1 head, 1 day..	9.70	25.90	4.90	.86	2.40

The work required of the animals was not severe in any case, the amount averaging two and four-tenths hours per day during the thirty days.

The trial was made during March and April. The work done by the two lots of horses was practically equal, and every animal used was on each kind of rough feed for thirty days.

Grain was supplied to them in a quantity necessary to nearly maintain them. They were all in good flesh when the trial began. Loss in weight is not unusual however, for horses which have been well fed and housed during winter, when they begin spring farm work.

The results indicate that in feeding straw to work stock, twenty-five per cent. more grain will be necessary to support them.

Forty per cent. less roughage was eaten by the stock when it was supplied in the form of oat straw, although they refused or wasted more of it, making the total supply only thirty-five per cent. less.

At a later time and since the publication of Bulletin No. 20 a short trial of seven days was made in feeding straw to work horses and mules. Several of them did heavy work in harvesting grain, working nine or ten hours per day. I found it impossible to prevent a loss of weight while feeding oat straw, but they were nearly maintained when given hay. Some ate the straw well, while others seemed always to consume it under protest.

BARLEY COMPARED WITH OATS FOR HORSES.

In a study of its value for work stock, barley was fed to three horses and two mules for nine months. Timothy hay was given as roughage during the trial. The mules did not eat the barley, with marked relish at any time, but for the first two months, while doing light work, they consumed all that was necessary to keep them in working condition. At the end of two months, when the amount of labor was increased, they would not eat a correspondingly greater amount of barley. They soon began to refuse it entirely for one, two, three and four feeding times. They were then changed to an oat ration each alternate month. When a change to oats came they would eat with apparent relish and would regain some of their lost flesh. One of the pair would refuse the barley more regularly than the other but neither could be maintained satisfactorily upon it. The trial was continued for nine months to determine whether they would persist regularly in refusing to eat it in sufficient quantity to maintain them when at moderate work but no improvement was noted.

Ordinary barley of the mansury variety was used in this trial. The barley was in good condition for feeding, but not bright enough to constitute good grain for malting.

A heavy two-horse work team was fed alternately upon oats and barley by twenty-eight-day periods, for two hundred, fifty-two days, the one horse being upon the barley ration while the other was upon the oat ration. They ate the barley readily without regard to the degree of work required of them. Timothy hay was fed for roughage during the trial.

The tabular statement shows that the barley did not prove quite so valuable per pound for the horses as oats. The two animals worked together upon the same evener, and during some four week periods when the work was heavy they lost in weight.

This occurred three times during the trial and in no case did one lose in weight for a period and the other gain or even fail to lose, but in every case the horse fed on barley lost more than the one fed on oats.

BARLEY COMPARED WITH OATS.

	Grain Eaten lbs.	Work Done hrs.	Gain or Loss in Weight lbs.
Feeding Oats.			
Total, 2 horses, 252 days..................	2,992.00	1,392.00	* 95.00
Average, 1 horse, 1 day....................	11.90	5.50	* .38
Feeding Barley.			
Total, 2 horses, 252 days..................	3,032.00	1,393.00	** 40.00
Average, 1 horse, 1 day....................	12.03	5.50	** .15

* Gain.
** Loss.

It was also observed that the horse fed on oats usually made a slightly heavier gain in weight when a gain was recorded.

This trial indicates that horses when taxed to the limit by hard work, cannot be supported upon barley quite so well as upon oats and that it is worth slightly less per pound than oats with stock which is given a medium amount of work. It indicates further that mules take less kindly to barley than do horses, and that horses which are inclined to be "dainty" eaters, will not eat barley so readily as oats.

Horsemen are unanimous in the opinion that no other grainfeed equals oats for the horse. It gives a degree of spirit or mettle which can be obtained from no other grainfeed. It has the further advantage of carrying so large a proportion of husk to berry that it is bulky, and for that reason it presents less liability to over feeding than barley.

MALTED BARLEY COMPARED WITH OATS.

Lawes and Gilbert of Rothamsted Experiment Station, England, report the result of an experiment in feeding twenty milking cows, twenty fattening oxen, sixty sheep and forty-eight pigs on barley malt as compared with barley [*]. The malt was compared with an amount of barley equal to that from which it was produced and a sample which had been taken from the same stock.

The trial was conducted in a very careful manner and covered two grades of barley, viz., good malting barley and second-grade barley.

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[*] Rothamsted Memoirs, Vol. IV.

Lawes and Gilbert writes: "The general conclusion from the results of the direct experiment with cows, oxen, sheep and pigs, is, that a given weight of barley is more productive, both of the milk of cows, and of the increase in live-weight of fattening animals, than the amount of malt and malt-dust that would be produced from it. * * * * * * * * * * Irrespective of economy, malt is undoubtedly a very good food for stock; and common experience seems to show that a certain amount of it is beneficial when given in admixture, and in change with other food to young or weakly animals or in 'making up' or 'finishing' for exhibition or sale; that is when the object is to produce a particular result irrespective of the economy required in ordinary feeding."

Malt was fed in comparison with oats to four horses, oat hay being used for roughage.

The barley was put in water for twenty-four hours after which it was spread out upon a floor six inches or less in depth and allowed to remain until the sprouts were one-half to three-fourths of an inch long, when it was fed.

One horse from each of two two-horse teams was fed malt while the other was given oats. They ate the malt readily but required somewhat more of it, as measured by the weight of dry barley from which it was made, than they did of oats. The following summarized table gives the results:

MALTED BARLEY COMPARED WITH OATS.

	Grain Eaten lbs.	Gain or Loss in Weight lbs.	Work Done hrs.
Feeding Oats.			
Total, 2 horses, 49 days	1,417.50	* 48.00	533.00
Average, 1 horse, 1 day	14.50	* .49	5.40
Feeding Malted Barley.			
Total, 2 horses, 49 days	1,434.00	** 74.00	532.00
Average, 1 horse, 1 day	14.60	** .76	5.40

* Gain.
** Loss.

The table shows that the horses did practically the same amount of work per day, being employed at light work, averaging five and four-tenths hour per day, or six and three-tenths hours for all of the working days during the trial.

One-tenth of a pound more of dry barley—in the form of malt—was given to each malt fed horse, than was required by those getting oats.

A gain of nearly a half pound per day was made by the animals when they were fed oats, while a loss of about three-fourths of a pound per day was the result when the ration consisted of malt.

The horses were fed for seven weeks in this trial; those getting malt during the first three weeks, were fed barley during the last four weeks, while those fed oats first, received barley during the latter period.

The feeding periods given were not consecutive, as two of the horses were sick with influenza for a week; and while they seemed perfectly normal in condition both before and after the trouble, an entire month of the record was thrown out as a precautionary measure against possible error. During the last four-week period. the work on working days was severe amounting to nine hours per day, but the results were proportioned to those obtained from the trial as a whole, i. e. that more grain was fed and the loss in weight was greater with the malt fed lot.

MALT AND BRAN COMPARED WITH OATS.

The horses used in the malt trial were next given, for two four-week periods, a mixture of malt and bran in comparison with oats. The malt and bran were mixed in the following proportion: The malt from two parts of dry barley was mixed with one part of bran by weight.

The horses were given a barley and bran ration, averaging nearly seventeen and four-tenths pounds of dry grain per day, and during some weeks as high as twenty-two pounds. They lost on an average, eight-tenths of a pound per day while eating the malt and bran mixture, but when they were given the oat ration, they gained nearly three-fourths of a pound per day, and received an average ration of only sixteen and two-tenths pounds of grain.

While receiving the bran and malt mixture the horses were not maintained in flesh, although they ate a much larger quantity of dry grain than they did when oats was fed.

The horses worked hard during this trial. The work averaged seven and seven-hundredths hours of work per day, or eight and twenty-five-hundredths hours for each working day. Oat hay was used for roughage. The following table gives the summarized results:

MALT AND BRAN COMPARED WITH OATS.

	Grain Eaten lbs.	Gain or Loss in Weight lbs.	Work Done hrs.
Feeding Oats.			
Total for 2 horses, 56 days	1,812.00	* 25.00	792.00
Average, 1 horse, 1 day	16.17	* .22	7.07
Feeding Malted Barley and Bran.			
Total for 2 horses, 56 days	1,947.00	** 90.00	792.00
Average for 1 horse, 1 day	17.38	** .80	7.07

* Gain.
** Loss.

These trials indicate that malted barley is not an economical feed for work horses, and that the addition of one part bran to two parts of malt, as measured by the dry barley, from which it was produced, is neither a cheap nor satisfactory feed for hard worked horses.

That splendid finish can be put on stock by feeding malt, has been pointed out by Lawes and Gilbert. These gentlemen base their conclusion upon trials in feeding seventy-four animals upon malt in comparison with an equal number of a similar sort upon other foods.

It is probable that animals which are not thriving or are worked down, and those which are low in vigor from any cause may often be built up rapidly by a ration containing malt.

CORN AS A HORSE FEED.

Two one-thousand-pound mules of good type were used in a feeding trial with corn for eighty-four days. They were worked together in a team during the trial, one receiving a ration of oats and corn and the other oats alone. Home grown ear corn was used for the trial and was fed at alternate feeds with oats, the same weight of corn and cob being fed as of oats when that ration was given. Little or none of the cobs were eaten.

The trial was conducted upon the basis of the amount of shelled corn consumed. The feeding in the trial was alternated between the two mules. When one was fed corn and oats the other received the oats alone. In that way the influence which the individuality of the animals would have exerted in the trial was counteracted.

The corn had a possible advantage in being fed to these mules which, I am informed, were when young, shipped here from Missouri. It is probable that they had been fed corn in that state. They seemed particularly fond of it, always eating it with apparent relish.

A smaller quantity of grain was fed when the corn and oat ration was used, as the plan of the trial was to maintain them while doing the amount of work required. It was found that less grain was needed when corn was used; accordingly the quantity given them was lessened.

The following tabulated statement gives the amount of oats fed in comparison with oats and corn, mixed in the proportion of one hundred pounds of corn to one hundred twenty-five pounds of oats:

CORN AND OATS COMPARISON WITH OATS.

	Grain Eaten lbs.	Gain or Loss in weight lbs.	Hours Work hrs.
Feeding Corn and Oats.			
Total, 2 horses, 84 days	1,304.00	** 115.00	1,044.00
Average, 1 horse, 1 day	7.70	* .70	6.20
Feeding Oats.			
Total, 2 horses, 84 days	1,472.00	** 100.00	1,046.00
Average, 1 horse, 1 day	8.80	** .60	6.20

* Gain.
** Loss.

The table shows that when the oat ration was fed, they required one and one-tenth pounds more grain per day to support them than they did when given oats and corn.

They did practically the same amount of work, (the difference being but two hours in eighty-four days). When oats was fed they lost an average of six-tenths of a pound per day, while the oats and corn gave an average gain of seven-tenths of a pound per day.

One hundred pounds of the oats and corn ration, consisted of fifty-five and six-tenths pounds of oats and forty-four and four-tenths pounds of corn.

By comparing the rations it may be seen that eighty-eight and five-tenths pounds of the corn and oat ration, equals one hundred pounds of oats unmixed, for feeding mules. Every eighty-eight and five-tenths pounds of oats and corn fed, consisted of forty-nine and two-tenths pounds of oats, and thirty-nine and three-tenths pounds of corn. It would seem fair to conclude that it was the thirty-nine and three-tenths pounds of corn, which caused the eighty-eight and five-tenths pounds of the mixed ration to equal 100 pounds of oats unmixed.

If the above conclusion is correct, one hundred pounds of oats is equal in feeding value to seventy-seven and five-tenths pounds of corn.

Oats at 25 cents per bushel equals 78.1 cents per 100 pounds.
Corn at 43¾ cents per bushel equals 78.1 cents per 100 pounds.

If seventy-seven and five-tenths pounds of corn equal 100 pounds of oats in feeding value, corn at fifty-six cents per bushel is as cheap as oats at twenty-five cents per bushel.

The mules were in good condition when the corn ration was fed and showed no bad effects from it in any way.

During the trial four weeks of time were thrown out on account of an epidemic of influenza. The animals were not affected by this malady longer than ten days, but more time was thrown out to make sure that the results of the experiment might be depended upon.

WHEAT AS HORSE FEED.

In Bulletin No. 20 of this Station the writer reported the result of feeding wheat to horses, but as that publication was sent out five years ago, and the copy has been misplaced by many persons who received it, I will briefly repeat the results obtained.

Three horses were fed No. 1 hard, unground wheat for four weeks, each animal being supplied about fourteen pounds daily.

These horses averaged nine hours work daily, during the trial, for all the working days of the month. During the trial the horses gained in weight. From the publication above mentioned I shall quote the following, concerning wheat as stock food: "It was with difficulty that the horses when fed this ration of pure wheat were kept from getting off feed and otherwise deranged in digestion. A large proportion of the kernels were passd through the alimentary tract unbroken while other grain were broken but only partially digested. * * * * * * * * * The test demonstrates clearly that it is not advisable to use wheat alone as a grain ration for horses, and the less expert the feeder the greater the risk."

In comparison with oats, a ration of two parts ground wheat and one part bran was, for four weeks, fed in a mixture to six horses. The results indicate that the mixture of ground wheat and bran is about equal to oats.

"The horses, as I have already said in Bulletin No. 20, did nicely on the ration consisting of two parts ground wheat and one part bran with prairie hay. Wheat is a concentrated food and needs this amount of bran to make it loose and cooling enough for the digestive system of the horse." Damaged wheat, if not moldy, is as good or better, than high-grade wheat for stock food, as it contains more protein or muscle-forming material.

BRAN AND SHORTS FOR HORSES.

A trial of feeding bran and shorts mixed, equal parts by weight, was made by the writer at this Station and published five years ago in Bulletin No. 20.

In the comparative trial of mixed bran and shorts against oats, twelve head of horses and mules were used, all of which were fed upon each feed used in the trial. In most cases half of the animals were fed for a twenty-eight or thirty-day period upon the one feed, and then an equal length of time upon the other.

BRAN AND SHORTS, EQUAL PARTS BY WEIGHT COMPARED WITH OATS.

	Grain Eaten lbs.	Gain or Loss in Weight lbs.	Work Done hrs.
Feeding Bran and Shorts.			
Total equal to 876 horses, 1 day	12,910	** 10.00	5,705.00
Weekly average per horse	103	** .08	45.50
Feeding Oats.			
Total equal to 792 horses, 1 day	11,838	* 10.00	4,796.00
Weekly average per horse	105	* .08	42.00

* Gain.
** Loss.

The amount of work could not be entirely controlled, but it differed too little to affect the results materially. The amount of work during the trial varied from very heavy work to absolute idleness, and in all cases the bran and shorts maintained them as well as the oats. In palatibility there is little difference, but the oats seemed to have the advantage.

Limited experience in feeding bran and shorts since 1895, without arranging the stock so as to obtain comparable results between the mill feeds and the oats corroborate the indications noted above.

SUMMARY.

The trials reported upon in this bulletin gave the following results:

1. Brome hay gave as good results when fed to work horses as did timothy hay.
2. Oat straw was satisfactorily used for feeding horses which did light work and for those which were idle. One-fourth more grain was required to support horses doing light work when they were fed straw.
3. Barley was not equal to oats in feeding value per pound, but was nearly as good. Mules did not relish barley.
4. Malted barley was not so valuable for work horses as oats and was not equal in value to the dry barley from which it came.
5. Corn fed in connection with oats in the proportion of 100 pounds of corn to 125 pounds of oats, had greater value than oats; 77.5 pounds of corn equalled 100 pounds of oats when fed to work horses.
6. Whole wheat fed alone was an unsatisfactory feed for horses. Wheat ground and mixed with bran in the proportion of two parts of wheat to one part of bran by weight gave good results.
7. Bran and shorts mixed in equal parts by weight, was equal to oats in feeding value.

J. H. SHEPPERD.

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 46.

A PRELIMINARY LIST OF THE SPERMAPHYTA, SEED BEARING PLANTS OF NORTH DAKOTA.

BY

HENRY L. BOLLEY

AND

LAWRENCE R. WALDRON.

Any farmer, teacher or student in the state can have this Bulletin mailed to his address, free of charge, upon application.

Fargo, North Dakota, U. S. A.
December, 1900.

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INTRODUCTION.

Botany as a general enlightener, as a mind polisher and thought developer is actually in the field, contending for a co-ordinate place in the general educational curriculum. The activity of its teachers and investigators as recorded in valuable educational results and in radical features of evolutionary growth, is, for the past decade, such as has been evidenced in no other branch of knowledge. From its ancient herbal glories in which it peacefully rested until a period scarce a quarter century since, when it had reached a stage in which many educators were willing to grant that it was a beautiful and interesting study for girls, it has suddenly emerged into a classified science, possessing a bearing upon daily life, work, and human understanding as broad as is the full relation of plant to animal life.

In every field of botanical investigation there is an activity exhibited, the results of which are constantly beyond the appreciation of any but the energetic specialist. The range of thought about plant life is so rich, extensive, and so open to variation, that there are botanists and botanists, specialists in numerous lines; systematists, agrostologists, pharmaceutical botanists, bacteriologists, algologists, mycologists, plant anatomists, plant physiologists, plant pathologists et al., and finally, that fine army of Experiment Station workers, at work upon every phase of plant life with a view to increasing the knowledge of economic facts which shall be available to the daily laborer in the field and the factory. Plant life—what is more important as a study; yet how general is ignorance with reference to the most simple principles affecting it.

This preliminary Flora of North Dakota is given out with the hope that it may promote interest in the general study of botany in the state, and especially that it may aid teachers in selecting materials suitable to make the work of instruction more interesting to the pupils. To accomplish this last named purpose, teachers will find that they need to know fundamental truths, to have a fund of observation facts concerning a few plants, and a number of fine specimens rather than a large collection of species. The list will be found of value in indicating what plants may be found in a given locality and in stimulating pupils to look for others. As teachers, let us get interested in one or two plants, live with them, and learn their lives thoroughly, where they grow, when, how and why; the conditions necessary to best growth; seed distribution and duration of life; form, shape, size, coloring and why; friends and foes; economic position with reference to man; and the literature of previous studies and investigations. A teacher with a few such plant friends cannot want for subject matter with which to interest a class. Pupils thus once interested in nature cannot grow up deficient in thought or grow wholly lonesome in after life; and men and women who possess such plant friends will be found able to build pleasant and happy surroundings for their home life.

HENRY L. BOLLEY.

Agricultural College, North Dakota.
December 6th, 1900.

A PRELIMINARY LIST
OF THE
SPERMAPHYTA OR SEED BEARING PLANTS
OF
NORTH DAKOTA.

BY

Henry L. Bolley and Lawrence R. Waldron,

North Dakota Agricultural College.

The Aim of the List: As yet there is no provisional list of the number and kinds of plants found within the limits of the state. A list, though but partly complete, will meet the approval of many people in the state, and should be of much value to teachers of botany: The mere knowledge of the fact that a certain plant grows in one locality is often a point of much value. It is hoped that the list now published may form the basis of further investigation, so that it may be a comparatively easy matter for anyone to add a separate contribution to the knowledge of the state flora. While it would be more scientific to construct a flora upon the basis of the natural topography of the state, it is possible to do such work properly only after many preliminary surveys. The work of constructing a natural flora based upon field studies of the separate ecological districts is the work of years and can be well done only by a collaboration of the efforts of many men. For such work, lists built upon lines of political areas are the first essential. It is with the view of starting an available one for general reference that this partial list for the state, is now prepared. It is thought that the list would be made of greater interest and value by a limited statement of known points of distribution, character, and use. These statements are added when it would seem that such purpose is served. Certain very valuable grasses, forage and medicinal plants are worthy of much more extended consideration than that here accorded to them, but such treatment would be inimical to the purposes of a list and is better left to separate publications. These will appear as special bulletins of the Experiment Station from time to time, and as the material for publication is available.

It is hoped, however, that sufficient facts have been stated to make the publication of quite general use to the people of the state, and especially to the teachers and pupils of the larger public schools. The soil of the state is so open to pasturage and to the plow that native plants are rapidly being exterminated, and there is not even the old snake fence to protect or to form a shelter for a few of each kind. Our purpose will be attained should our remarks make a few friends in each county of the state for a number of the valuable and beautiful native plants which are rapidly being destroyed by cultivation, or if we succeed in warning a like number against the pernicious weedy character of some of the introduced plants which are ever ready to follow in the wake of the careless plowman.

NOMENCLATURE: The list as constructed follows the order and nomenclature of Gray's Revised Manual of Botany and Coulter's Manual of Rocky Mountain Botany. This is deemed desirable as these texts are the ones in general school and public use. In case the plant has been renamed in the Illustrated Flora of the Northern States and Canada, by Britton and Brown, this new naming is affixed in italics; and the Latin names are followed by such common names as, it is thought, are in best use. No attempt is made to give a full listing of the common names, as they have little value aside from the slight aid and interest afforded to local students and amateur collectors. It is difficult to find a common name which has any very general use.

METHOD OF LISTING AND ABBREVIATIONS USED: As indicated in the title, this is far from a complete listing of the Spermaphyta of the state. No doubt some quite common species are not listed. Only such are printed as are represented by specimens in the Agricultural College Herbarium or in that of the University of North Dakota. Following the naming of a species the habitat and economic characters are given, if known and deemed of value. This is followed by the name of the locality from which the specimen recorded was collected, and a statement of the herbarium in which it is now deposited. In case a species is represented in the Agricultural College Herbarium in a number of collections, the specimens listed are those from points of collection which best represent the range or distribution of the species in the state. The number following the name of the town represents the recorded or determined herbarium specimen. Aside from the two special abbreviations—A. C. Herb. for Agricultural College Herbarium, and Univ. Herb. for University Herbarium, the authors have tried to conform to the usual botanical abbreviation methods for the names of authorities and authors—thus, L. for Linnaeus, Coult. Man. for Coulter's Manual of Rocky Mountain Botany, Britt. and Br. Fl. for Britton and Brown's Flora of Northern States and Canada, and U. S. P. for United States Pharmaeopœia.

Acknowledgement of Assistance: The herbarium from which this list is compiled was chiefly collected during the summers of 1891 and '92. Since that time many separate collections have been added, increasing our knowledge of distribution and adding to the number of species found. Other college and private herbaria have also been much perfected during that time. To the owners of these, the authors wish to extend thanks for lists and specimens sent for examination enabling them to make this first publication of the plants of the state as complete as possible. The University Herbarium has been credited with all specimens listed by Professor M. A. Brannon, and the locality of collection noted. Professor Brannon's list is not quite co-extensive with the Agricultural College Herbarium list, and shows the collection of 48 species not now in the Agricultural College Herbarium. Miss Lura Perrine, Valley City, Mr. C. C. Schmidt of Jamestown, Mr. F. L. Fieldstad of Lisbon and Mr. Christian Westergaard of Glen Ullin have each quite admirable private collections. These have been generously submitted for examination and verfication and a specimen of each species new to the Agricultural College Herbarium deposited therein. Mr. T. A. Haigh, of Mankato, Minnesota, has also, while on the government survey in Ward and Williams Counties, made a collection of some seventy-five or eighty specimens which he generously deposited in the Agricultural College Herbarium. In the case of such new acquisition, the list gives credit to the collector under the name of the species. The number of specimens thus furnished by each correspondent is as follows: Haigh 9, Westergaard 3, Schmidt 4, Fieldstad 19, and Perrine 27. The collection of Miss Perrine is of wide range and particularly complete in the plants of Barnes County and southward. It is hoped that the Valley City Normal authorities may see the desirability of furnishing Miss Perrine with facilities for this work, and of making the collection a permanent feature of that institution.

Exchange of Specimens: In this publication, the work of listing the plants of the state is really only begun, and we predict that the future survey of the field will be so rapid that an early revision of this list will be made necessary. To this end, it is hoped that everyone into whose hands this catalogue may fall will take an interest to the extent of sending a few collections to the permanent herbaria, where they may be officially classified and filed for reference.

If desired, the Agricultural College Herbarium will furnish exchange specimens for all specimens sent in which are of the standard form. This will enable the various schools of the state to increase the usefulness of their collections. We have a large number of duplicate specimens of most species listed. They are for exchange for good standard specimens from any part of America. Write what you want and send specimens to cover, and we will exchange to the extent of our ability, returning specimens not accepted. Specimens of algæ, lichens, ferns, mosses and fungi from Dakota are especially desired, as we are now arranging for the publication of a list of these plants found growing in the state.

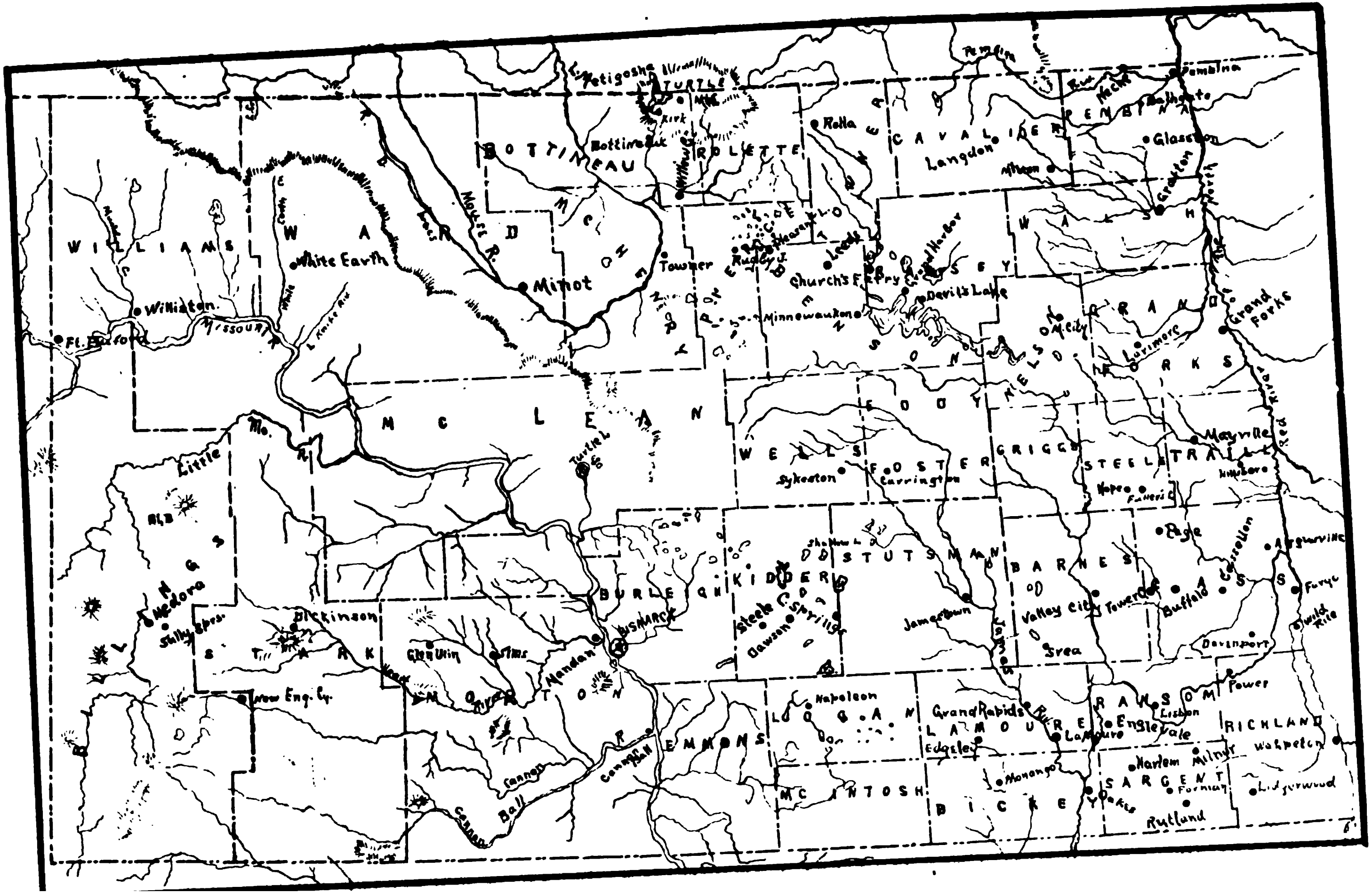
THE LIST: No excuse need be made for the apparent deficiencies of the list. The survey of the state has, with the exception of that conducted during three summer months, been nothing like systematic in effort. The list is more properly indicated by the term collection than by the idea represented by a plant survey. There are some noticeable peculiarities due to the rather large and uniform ecological areas of the state, among which may be noted the rather low total number of species with comparatively high number of genera and orders. Though incomplete, the list fairly well represents the condition of the flora in the state. There is not a wide range of native species. Deep-rooted perennials or biennials occupy most of the native sod. The swamp areas have a sameness of character, and the wooded or shrubby regions are few and limited in area. The number of introduced plants is rapidly increasing with cultivation, and the next list will undoubtedly show a great change in this respect. As regards public school work in observation and classification, the relatively large range of genera readily makes good the deficit in the number of different species to be found in a given locality. Because of the fact, however, that our winter weather shuts down early and the spring weather opens late, there is not at either end of our present public school year a period of plant growth long enough for extended study of plants. This condition could easily be provided against, and we earnestly recommend to teachers, trustees and directors that provision be made in each school for the storage of herbarium sheets, plant specimens, seeds and fruits; for aside from the valuable opportunity offered to the advanced pupils, such a collection and the opportunity to make it will furnish many an object lesson in nature-study, the introduction of which is now being attempted. Nature-study cannot go on without specimens, and specimens will seldom be collected or be of any use, unless there is provided a proper place for storage, free from mice, insects, and dust.

SUMMARY AND POINTS OF COLLECTION: Of the seed-bearing plants of the state, this preliminary list records the collection of specimens representing 82 orders, 340 genera, and 775 species and varieties.

The principal points of collection are designated upon the map on page 598, and are listed below with a statement of the elevation of each place:

	FEET.
Argusville	884
Bathgate	821
Bismarck	1670
Bottineau	1638
Buffalo	1202
Carrington	1579
Casselton	934
Church's Ferry	1458
Crystal Springs	1792
Davenport	923
Dawson	1748
Devil's Lake	1434
Dickinson	2405
Edgeley	1556
Fargo	905
Forman	1249
Ft. Buford	1994
Glasston	836
Glen Ullin	2070
Grafton	827
Grand Forks	830
Grand Harbor	1454
Grand Rapids	1321
Hillsboro	901
Hope	1241
Jamestown	1408
LaMoure	1307
Langdon	1610
Leeds	1514
Lidgerwood	1122

	FEET
Lisbon	1091
Mandan	1646
Mayville	978
Medora	2267
Michigan City	1517
Milnor	1097
Milton	1586
Minot	1557
Monango	1503
Napoleon	1955
Neche	831
Oakes	1320
Page	1175
Rolla	1818
Rugby	1561
Rutland	1225
Sims	1962
Spiritwood	1479
Steele	1859
Sully Springs	2575
Tower	1172
Towner	1475
Turtle Mt	2150
Valley City	1227
Verona	1387
Wahpeton	965
White Earth	2087
Williston	1857
Willow City	1471


WILLIAMS
Ft. Buford
Williston
Missouri R.
WARD
White Earth
L. Knife Riv
Mouse R.
Minot
BOTTINEAU
Bottineau
L. Metigoshe
TURTLE MT.
Kirk
Willow City
ROLETTE
Rolla
TOWNER
Towner
Rugby J.
PIERCE
BENSON
Leeds
Church's Ferry
Minnewaukon
Devil's Lake
RAMSEY
Grand Harbor
CAVALIER
Langdon
Milton
PEMBINA
Pembina
Bathgate
Glasston
Grafton
WALSH
Park R.
GRAND FORKS
Grand Forks
Larimore
NELSON
Lakota
Red River
TRAILL
Mayville
Hillsboro
STEELE
Hope
GRIGGS
EDDY
FOSTER
Carrington
WELLS
Sykeston
McLEAN
Turtle L.
Little Mo. R.
BILLINGS
Medora
Sully Sprs.
STARK
Dickinson
New Eng. Cy.
MORTON
Glen Ullin
Sims
Mandan
BISMARCK
BURLEIGH
KIDDER
Steele
Dawson
Spring
STUTSMAN
Jamestown
BARNES
Valley City
Tower City
Sanborn
CASS
Fargo
Buffalo
Casselton
Page
Arthur
Wild Rice
Davenport
EMMONS
Cannon Ball
Cannon Ball
LOGAN
Napoleon
LA MOURE
Grand Rapids
La Moure
Edgeley
McINTOSH
DICKEY
Monango
Oakes
RANSOM
Lisbon
Englevale
SARGENT
Harlem
Milnor
Forman
Rutland
RICHLAND
Wahpeton
Lidgerwood
Power

RANUNCULACEAE. BUTTERCUP, OR CROWFOOT FAMILY.

CLEMATIS VIRGINIANA L. Virginina Virgin's Bower. Common in low woodlands and thickets throughout the state. A climbing vine with small clusters of small white flowers. Very effective for ornamental purposes. A. C. Herb.: Fargo 1, Medora 2, Ft. Buford 3. Univ. Herb.: Grand Forks.

ANEMONE PATENS NUTTALLIANA Gray. *Pulsatilla hirsutissima* (Pursh) Britt. American Pasque Flower. On fertile open dry prairies throughout the state, scattering. Very early spring flower. Ornamental. A. C. Herb.: Rolla 4, Church's Ferry 5, Valley City 6, Verona, Jamestown. Univ. Herb.: Grand Forks.

ANEMONE MULTIFIDA Poir. Cut-leaved Anemone. Ornamental. A. C. Herb.: Rolla 9.

ANEMONE CYLINDRICA Gray. Long-fruited Anemone. Moist woodlands and open prairies of the state. Ornamental herb. A. C. Herb.: Fargo 7, Neche 8.

ANEMONE PENNSYLVANICA L. *Anemone Canadensis* L. Canadian Anemone. Woodlands, low meadows and waysides. General throughout the state. Ornamental herb. A. C. Herb.: Fargo 10, Jamestown 11, LaMoure 12, White Earth. Univ. Herb.: Grand Forks.

ANEMONE NEMOROSA L. *Anemone quinquefolia* L. Wood Anemone, or Wind-flower. In open rich woodland mould. Very early spring flower. Ornamental. Univ. Herb.: Grand Forks.

THALICTRUM DIOICUM L. Early Meadow-Rue. In woodlands and shrub undergrowths of prairies, especially along river courses. A perennial herb with fern-like foliage. Ornamental in shrubberies. A. C. Herb.: Fargo 17. Univ. Herb.: Grand Forks.

THALICTRUM PURPURASCENS L. Purplish Meadow-Rue. Wooded river banks of the state. A large perennial herb of distinctly ornamental value as a foliage plant amid lawn shrubbery. A. C. Herb.: Fargo 14, Hope 15, Neche 16. Univ. Herb.: Grand Forks.

RANUNCULUS AQUATILIS TRICHOPHYLLUS Gray. *Batrachium trichophyllum* (Chaix) Bossch. Water-Crowfoot. Rivers and ponds. A weak floating herb. A. C. Herb.: Rolla 20, Valley City. Univ. Herb.: Grand Forks.

RANUNCULUS CYMBALARIA Pursh. *Oxygraphis Cymbalaria* (Pursh) Prantl. Seaside Crowfoot. Throughout the state in low or alkaline spots. A. C. Herb.: Fargo 21, Tower City 22, LaMoure, Jamestown. Univ. Herb.: Grand Forks.

RANUNCULUS MULTIFIDUS Pursh. *Ranunculus delphinifolius* Torr. Yellow Water Crowfoot. An aquatic, branching, partly floating, flowering herb in lakes and ponds. A. C. Herb.: Valley City 1156. Coll., Perrine. Univ. Herb.: Grand Forks.

RANUNCULUS RHOMBOIDEUS Goldie. *Ranunculus ovalis* Raf. Prairie Crowfoot. Everywhere on the prairie. Early. A low herb. A. C. Herb.: Fargo 23.

RANUNCULUS ABORTIVUS L. Small-flowered Ranunculus. Wooded river banks and low wet places. Biennial herb. A weed in low-lying soil. A. C. Herb.: Fargo 25, Wahpeton 24, Bismarck. Univ. Herb.: Grand Forks.

RANUNCULUS SCELERATUS L. Cursed Crowfoot. Celery-leaved Crowfoot. Ditch Crowfoot. Pond margins and along ditches. Juice very acid, said to be poisonous. A. C. Herb.: Rolla 26, Fargo 27.

RANUNCULUS SEPTENTRIONALIS Poir. Swamp or Marsh Buttercup. In low ground and swamps. A. C. Herb.: Valley City 1154. Coll., Perrine.

RANUNCULUS HISPIDUS Michx. Britt. & Br. Fl. Hispid Buttercup. In dry woods and thickets. A. C. Herb.: Valley City 1310. Coll., Perrine.

RANUNCULUS PENNSYLVANICUS L. f. Bristly Buttercup or Bristly Crowfoot. Throughout the state in wet or marshy ground. A coarse hairy herb. A. C. Herb.: Valley City 28, Fargo 29, Oakes, Bismarck, Page City, Lisbon, Medora. Univ. Herb.: Grand Forks.

RANUNCULUS HISPIDUS Hook. *Ranunculus Macounii* Britt. Hispid Buttercup. Damp alluvial soil. Herb much like last species. A. C. Herb.: Fargo 30.

AQUILEGIA CANADENSIS L. Wild Columbine. Woodlands throughout the state. A beautiful spring plant growing from perennial roots. In this region it gives by its foliage and flowers a fine ornamental effect amid lawn shubbery. A. C. Herb.: Rutland 31, Fargo, Lisbon.

Delphinium azureum Michx. *Delphinium Carolinianum* Walt. Azure Larkspur or Carolina Larksjur. Throughout the prairie regions of the state. Perennial from roots. Ornamental, but leaves and seeds are said to be poisonous. *D. tricorne* not yet found in the state is markedly poisonous to cattle. A. C. Herb.: Hillsboro 32, Page City 33, Power, Jamestown, Lisbon: Univ. Herb.: Grand Forks.

Actaea spicata rubra Ait. *Actaea rubra* (Ait.) Willd. Red Baneberry. Red Cohosh. In rich damp soil of dark woodlands. Roots said to be medicinal but are not recognized in U. S. P. A. C. Herb.: Neche 34, Turtle Mts. 35, Bathgate.

Actaea alba Bigel. *Actaea alba* (L.) Mill. White Baneberry. Found in rich woodands. Character much as last species. Univ. Herb.: Grand Forks.

MENISPERMACEAE. MOONSEED FAMILY.

Menispermum Canadense L. Canada Moonseed. Upon shrubbery near river banks. A good climber from perennial roots. Ornamental; A. C. Herb.: Fargo 56. Univ. Herb.: Grand Forks.

BERBERIDACEAE. BARBERRY FAMILY.

Berberis vulgaris L. Common Barberry. A thorny shrub introduced for ornamental purposes. Harbors one of the stages of the parasite which produces wheat rust. While apparently not necessary to the continued existence of rust, it is admitted that wheat rust is often much worse in the immediate vicinity of this rust-bearing plant. As it is not a native plant one should not be commended for introducing it. A. C. Herb.: Fargo 733.

Caulophyllum thalictroides Michx. Blue Cohosh. Squaw Root. Yellow Ginseng. A pretty plant found in deep woods, the roots and rootstocks of which constitute an official drug. The roots should be collected in spring or early summer. A. C. Herb.: Fargo 1247.

PAPAVERACEAE. POPPY FAMILY.

Sanguinaria Canadensis L. Blood-root. Red Puccoon. Indian Paint. In alluvial woodlands. Quite abundant along the banks of the Red River. The rhizomes constitute an official drug. They should be collected in late summer or autumn. A. C. Herb.: Fargo 772. Univ. Herb.: Grand Forks.

FUMARIACEAE. FUMITORY FAMILY.

CORYDALIS AUREA Willd. *Capnoides aureum* (Willd.) Kuntze. Golden Corydalis. In rather dry sandy woodlands. A pretty spring herb of reputed medicinal value, but not officially recognized. A. C. Herb.: Rolla 42, Rutland 43, Lisbon 44. Univ. Herb.: Grand Forks.

CRUCIFERAE. MUSTARD FAMILY.

ARABIS PATENS Sulliv. Spreading Rock-cress. A biennial weed in waste places. Univ. Herb.: Grand Forks.

ARABIS HIRSUTA Scop. Hairy Rock-cress. In dry rocky places throughout the state. A small herb of weedy character. Said to be of some value as a salad plant. A. C. Herb.: Fargo 45, Jamestown 46, Oakes. Univ. Herb.: Grand Forks.

ARABIS CONFINIS Wats. *Arabis brachycarpa* (T. & G.) Britt. Purple Rock-cress. Encroaching upon cultivated ground as a weed. A. C. Herb.: Devil's Lake 47, Oakes, Fargo.

DRABA NEMOROSA L. Wood Whitlow-grass. Throughout our range. A. C. Herb.: Valley City 1169. Coll., Perrine.

LESQUERELLA LUDOVICIANA Wats. *Lesquerella argentea* (Pursh) MacM. Silvery Bladder-pod. On dry prairies throughout the state, in gravel or sand. A. C. Herb.: Valley City 48, Medora Flats 49.

LESQUERELLA SPATULATA Rydb. Britt. & Br. Fl. Low Bladder-pod. A. C. Herb.: Ward Co. 1267. Coll., Haigh.

LESQUERELLA ALPINA Nutt. Coult. Man. In Bad Lands west of Missouri River. A dwarf, or alpine species. A. C. Herb.: Medora 50.

CAMELINA SATIVA Crantz. False Flax. Gold-of-Pleasure. Scattered with cultivated crops throughout the state, especially in flax. A bad annual weed. In Europe a fine grade of oil is made from its seeds and the plant is said to be a nutritious food for cattle. A. C. Herb.: Bottineau 51, Sykeston 52, Fargo. Univ. Herb.: Rugby Junction.

NASTURTIUM PALUSTRE DC. *Roripa palustris* (L.) Bess. Marsh Cress. Yelow Water-cress. In wet places throughout the state, a rough branching weed. A. C. Herb.: Bottineau 1032, Sykeston 1033.

NASTURTIUM OBTUSUM Nutt. *Roripa obtusa* (Nutt.) Britt. Blunt-leaved Yellow-cress. General throughout the range, in low lands. A. C. Herb.: Fargo 1030, Turtle Mts. 1031, Harlem, Bathgate, Wild Rice.

NASTURTIUM PALUSTRE HISPIDUM Gray. *Roripa hispida* (Desv.) Britt. Hispid Yellow-cress. Found in wet places. A. C. Herb.: LaMoure 1029.

NASTURTIUM ARMORACIA Fries. *Roripa Armoracia* (L.) Hitchc. Horseradish. Escaped from cultivation. A. C. Herb.: Fargo 1354.

ERYSIMUM ASPERUM DC. Western Wall Flower or Yellow Phlox. Everywhere on dry hard prairie sod. Not a very bad weed. A. C. Herb.: Sykeston 53, Lake Metigoshe, Valley City, Church's Ferry. Univ. Herb.: Grand Forks.

ERYSIMUM CHEIRANTHOIDES L. Worm Seed Mustard. Treacle Mustard. In open prairies and upon margins of cultivated fields. A weed of considerable strength. A. C. Herb.: Fargo 55, Neche 56, LaMoure, Bismarck, Church's Ferry. Univ. Herb.: Grand Forks.

ERYSIMUM PARVIFLORUM Nutt. *Erysimum inconspicuum* (Wats.) MacM. Small Erysimum. Open prairie regions. A. C. Herb.: LaMoure 57, Fargo 58, Valley City, Hope.

CONRINGIA ORIENTALIS (L.) Dumort. Britt. & Br. Fl. Hare's-ear Mustard. Treacle Mustard. Generally introduced in grain fields. Coming first from the Manitoba region. It is becoming abundant everywhere. It has very long pods, is a heavy seed producer, and a hard plant to pull. One of the worst forms of the mustard weeds. A. C. Herb.: Bathgate 59, Fargo 60, Ransom Co. First observed at Fargo in 1892.

SISYMBRIUM INCISUM Engelm. Coult. Man. *Sophia incisa* (Engelm.) Greene. Western Tansy-Mustard. A. C. Herb.: Ward Co. 1268, Fargo 1302.

SISYMBRIUM HARTWEGIANUM Fourn. *Sophia Hartwegiana* (Fourn.) Greene. Plants of this species are mainly referred to

Sisymbrium canescens in Gray's Manual. A. C. Herb.: Lisbon 61, Fargo 62, Devil's Lake, Rutland. Univ. Herb.: Grand Forks, Langdon.

SISYMBRIUM OFFICINALE Scop. An unsightly weed around dwellings, recently introduced from eastern states. A. C. Herb.: Fargo 1303.

SISYMBRIUM ALTISSIMUM L. Tumbling Mustard. Tall Sisymbrium. Being rapidly introduced into grain fields. Originally introduced into Canada from Europe. Must eventually become one of the worst types of mustard to combat in cultivated fields. It branches profusely, seeds heavily and when mature breaks off at root and tumbles before the wind. A. C. Herb.: Monango 63, Neche 64, Lisbon. First observed at Neche in 1891, later at Fargo in 1895.

THELYPODIUM INTEGRIFOLIUM Endl. Coult. Man. Entire-leaved Thelypodium. Western portion of the state. A. C. Herb.: Dawson 1034.

BRASSICA SINAPISTRUM Boiss. *Brassica arvensis.* (L.) B. S. P. Charlock. Wild Mustard. A weed everywhere in grain fields. A. C. Herb.: Fargo 65, Hope, Mandan, Church's Ferry, Bismarck, Sykeston, Davenport. Univ. Herb.: Grand Forks.

BRASSICA ALBA Boiss. *Sinapis alba* L. White Mustard. An introduced mustard. May become weedy, but not so bad as the next species. The seeds of the plant furnish much of the mustard of commerce and druggist supplies. Univ. Herb.: Grand Forks.

STANLEYA PINNATIFIDA Nutt. Coult Man. *Stanleya pinnata* (Pursh) Britt. Stanleya. A plant of Missouri River regiou. A coarse branching perennial. A. C. Herb.: Medora 67.

CAPSELLA BURSA-PASTORIS Moench. *Bursa Bursa-pastoris* (L.) Britt. Shepherd's Purse. Case-weed. Mother's Heart. A weed everywhere, especially troublesome in lawns and meadows. A. C. Herb.: Fargo 68, Valley City. Univ. Herb.: Grand Forks.

THLASPI ARVENSE L. Penny Cress. Bastard Cress. French Weed. One of the worst weeds in the northwest. Introduced from Manitoba, and there from Europe. A. C. Herb.: Fargo 70, Neche 71, Turtle Mts.

LEPIDUM INTERMEDIUM Gray. *Lepidum apetalum* Willd. Apetalous Pepper-grass. A common field and roadside weed everywhere. A. C. Herb.: Fargo 72, Valley City, Sykeston, Bathgate. Univ. Herb.: Minot.

Lepidum sativum L. Garden Pepper-grass. Town Pepper-grass. Golden Pepper-grass. Cress. Introduced. Cultivated as a salad plant. Looks as if it might become a bad weed. A. C. Herb.: Bathgate 1037.

Physaria didymocarpa Gray. Coult. Man. Double Bladder-pod. A dwarfish appearing plant found on dry bluffs of the western part of the state. A. C. Herb.: Medora 1035.

Neslia paniculata (L.) Desv. Britt. & Br. Fl. Ball Mustard. Neslia. Being introduced at the north, a bad type of weed. The seeds remain inclosed in small spherical pods and become troublesome in threshed grain. A. C. Herb.: Turtle Mts. 1036, Bathgate.

CAPPARIDACEAE. CAPER FAMILY.

Polanisia graveolens Raf. Clammy-weed. A large, rough, clammy, ill-smelling annual, along sandy shore lines. A. C. Herb.: Mandan 73, Dawson 74.

Cleome integrifolia T. & G. *Cleome serrulata* Pursh. Pink Cleome. A rough branching annual, abundant westward, flowers showy. May have some ornamental value if properly placed. A. C. Herb.: Bismarck 75, Medora 76, Mandan. Univ. Herb.: Grand Forks.

CISTACEAE. ROCK-ROSE FAMILY.

Hudsonia tomentosa Nutt. Woolly Hudsonia. False Heather. Beech Heather. Found growing on barren sand hills. This plant is generally found on lake shores. A. C. Herb.: Ransom Co. 1351. Coll., Perrine.

VIOLACEAE. VIOLET FAMILY.

Viola pedata L. Bird's-foot Violet. On open prairies everywhere. This or any one of the following violets may be easily cultivated. A. C. Herb.: Fargo 79.

Viola pedatifida G. Don. Prairie Violet. A. C. Herb.: Fargo 1087.

Viola palmata L. A. C. Herb.: Fargo 1208.

Viola palmata cucullata Gray. *Viola obliqua* Hill. Early Blue Violet. Found everywhere in wooded and partly wooded strips upon well drained land. A. C. Herb.: Fargo 78, Valley City, Lisbon. Univ. Herb.: Grand Forks.

Viola Nuttallii Pursh. Nuttall's Violet. On open prairies. A. C. Herb.: Valley City 1059. Coll., Perrine. Jamestown 763. Coll., Schmidt.

Viola pubescens Ait. Hairy Yellow Violet. In dry woodlands. A. C. Herb.: Fargo 775. Univ. Herb.: Grand Forks.

Viola Canadensis L. Canada Violet. A rather showy strong growing violet found everywhere in rich woodlands. Ornamental plant. A. C. Herb.: Neche 80, Valley City 81, Lisbon, Fargo, Rolla, Wahpeton, Turtle Mts. Univ. Herb.: Grand Forks.

Viola canina Muhlenbergii Gray. *Viola Labradorica* Schrank. Dog Violet. Found in rather wet shaded places, sandy and rocky shore lines. A. C. Herb.: Valley City 1146. Coll., Perrine.

CARYOPHYLLACEAE. PINK FAMILY.

Saponaria Vaccaria L. *Vaccaria Vaccaria* (L.) Britt. Cowherb. Soapwort. Bouncing Bet. Cow Pink. An introduced annual weed. A heavy grower from the seed, becoming too abundant in grain fields. Its large black or brown seed may often be mistaken for cockle, and elevator men reduce the grade of grain when it is present. A. C. Herb.: Sykeston 82, Hope 83, Argusville, LaMoure, Page, Mayville, Milton, Jackson. Univ. Herb.: Grand Forks.

Silene Virginica L. Fire Pink. In dry woodlands, rare. A. C. Herb.: Valley City 84.

Silene antirrhina L. Sleepy Catchfly. A low branching annual, rare. A. C. Herb.: Fargo 85.

Silene noctiflora L. Night-flowering Catchfly. Sparsely introduced. A. C. Herb.: Wild Rice 86, Hillsboro.

Lychnis Githago Lam. *Agrostemma Githago* L. Corn Cockle. Corn Rose. Corn Campion. Rough Cockle. In grain fields. A bad weed in wheat. The seeds are poisonous and the flour made from grain containing much Lychnis seed is injurious to health. Elevator and mill men reduce the grade of grain when the seed of this plant is present. A. C. Herb.: Leeds 87, Jamestown 88, Hillsboro, Page, Lisbon, Bismarck. Univ. Herb.: Grand Forks.

ARENARIA LATERIFLORA L. *Moehringia lateriflora* (L.) Fenzl. Blunt-leaved Sandwort. In moist places along shore lines. A. C. Herb.: Jamestown 89. Univ. Herb.: Grand Forks.

STELLARIA MEDIA Smith. *Alsine media* L. Common Chickweed. Introduced weed, common in both open and woodland places. It tends to occupy the ground quite thoroughly in damp areas. A. C. Herb.: Fargo 1254.

STELLARIA LONGIFOLIA Muhl. *Alsine longifolia* (Muhl.) Britt. In swampy lands. A. C. Herb.: Fargo 90, Wahpeton, Rolla, Valley City.

STELLARIA LONGIPES Goldie. *Alsine longipes* (Goldie) Coville. Long-stalked Stitchwort. In rich damp places. A. C. Herb.: Leeds 92, Fargo 93.

CERASTIUM VULGATUM L. Larger Mouse-ear Chickweed. General throughout our range. A. C. Herb.: Valley City 95, Fargo, Jamestown, Medora.

CERASTIUM NUTANS Raf. *Cerastium longipedunculatum* Muhl. Nodding Chickweed. Powder-horn. A. C. Herb.: Lake Metigoshe 96.

CERASTIUM ARVENSE L. Field Chickweed. Univ. Herb.: Grand Forks.

SPERGULA ARVENSIS L. Spurry. Sandweed. Corn Spurry. An annual weed introduced into grain fields. A. C. Herb.: Fargo 97.

PORTULACACEAE. PURSLANE FAMILY.

PORTULACA OLERACEA L. Purslane or Pussley. A naturalized weed, very troublesome in gardens and hoed crops. A. C. Herb.: Fargo 98.

MALVACEAE. MALLOW FAMILY.

MALVA ROTUNDIFOLIA L. Dwarf Mallow. Creeping Mallow. Cheeses. Naturalized from Europe. A bad weed around houses. A. C. Herb: Fargo 1234.

MALVASTRUM COCCINEUM Gray. False Mallow. Red Mallow.

Everywhere a native of the open dry prairies. Rather ornamental in appearance. Perennial. A good plant for class study. A. C. Herb.: Bottineau 99, Rutland 100, Valley City, LaMoure, Sykeston, Leeds, Tower City, Church's Ferry. Univ. Herb.: Grand Forks.

HIBISCUS TRIONUM L. Bladder Ketmia. Flower-of-an-hour. Venice Mallow. Black-eyed Susan. An introduced annual weed in gardens. A. C. Herb.: Fargo 766.

TILIACEAE. LINDEN FAMILY.

TILIA AMERICANA L. Basswood. White-wood. American Linden. A valuable forest tree along streams. Lumber of good quality, soft, white. A very fine shade tree. Thrives well in this region if given an abundant supply of water. Found along the Red River and other streams. A. C. Herb.: Fargo 101. Univ. Herb.: Grand Forks.

LINACEAE. FLAX FAMILY.

LINUM SULCATUM Riddell. Grooved Yellow Flax. In dry places throughout the state. Annual. A. C. Herb.: Englevale 103, Davenport 104, Fargo, Lisbon. Univ. Herb.: Grand Forks.

LINUM RIGIDUM Pursh. Large-flowered Yellow Flax. On dry prairies everywhere. A perennial. A. C. Herb.: Lake Metigoshe 105, Lisbon 106, Mandan, Medora, LaMoure, Valley City, Fargo. Univ. Herb.: Grand Forks.

LINUM PERENNE LEWISII Eat. & Wright. *Linum Lewisii* Pursh. Lewis' Wild Flax. Everywhere upon the open prairies. A. C. Herb.: Medora 107, Englevale, Hope, Fargo.

LINUM USITATISSIMUM L. Common Flax. Escaped from cultivation. A. C. Herb.: Valley City 108, Sykeston 109.

GERANIACEAE. GERANIUM FAMILY.

GERANIUM CAROLINIANUM L. Carolina Cranesbill. Common throughout the state, especially in wooded places. Might be made use of as an ornamental herb. A. C. Herb.: Bottineau 110, Rutland, Rolla.

OXALIS VIOLACEA L. Violet Wood-sorrel. In cultivated grain fields and in woodlands, growing from perennial scaly bulbs. Small, else quite weedy in character. Rather ornamental. A. C. Herb.: Fargo 112, Lisbon 111.

OXALIS CORNICULATA STRICTA Sav. *Oxalis stricta* L. Upright Yellow Sorrel. Found everywhere in grain fields and meadows. Annual or perennial. Quite a weed in early summer, but weak. Ornamental in wild garden. A. C. Herb.: Neche 113, Valley City, Fargo, Bismarck. Univ. Herb.: Grand Forks.

IMPATIENS FULVA Nutt. *Impatiens biflora* Walt. Spotted Touch-me-not. Silver Leaf. Balsam. Found in moist woods. A. C. Herb.: Svenby 1366. Coll., Perrine.

RUTACEAE. RUE FAMILY.

XANTHOXYLUM AMERICANUM Mill. Prickly Ash. Tootache-tree. Northern Prickly Ash. On the wooded banks of Red River. It is a harsh thorny shrub. The bark constitutes an official drug. See U. S. P. A. C. Herb.: Wild Rice 115, Fargo 778.

CELASTRACEAE. STAFF-TREE FAMILY.

CELASTRUS SCANDENS L. Shrubby Bittersweet. Climbing Bittersweet. Wax-work. Staff-tree. Found in wooded lands along the rivers. A beautiful climbing shrub very successfully grown for ornamental purposes. A. C. Herb.: Turtle Mts. 116, Fargo, Valley City.

VITACEAE. VINE FAMILY.

VITIS RIPARIA Michx. *Vitis vulpina* L. Wild Grape. Riverside Grape. A small wild grape extensively climbing upon trees and shubbery along rivers. Fruit very sour but edible about frost time. In this state this is the most serviceable vine for arbors or porch decorations. A. C. Herb.: Rutland 117, Fargo 118.

AMPELOPSIS QUINQUEFOLIA Michx. *Parthenocissus quinquefolia* (L.) Planch. Virginia Creeper. False Grape. American Ivy. Everywhere in the wooded districts. Very generally used as a climbing vine for walls and arbors and for shading purposes. The autumn coloring of its five-pointed leaves adds much to its ornamental value. A. C. Herb.: Devil's Lake 170, Fargo, Ft. Buford.

SAPINDACEAE. SOAPBERRY FAMILY. MAPLE FAMILY.

ACER SACCHARINUM Wang. *Acer Saccharum* Marsh. Sugar or Rock Maple. One of the most valued of hard wood forest trees.

Used for hard wood finish in furniture, flooring, etc. Furnishes best quality of wood for fuel. Usually considered as one of America's best shade trees. It grows well in North Dakota for this purpose, if kept thoroughly watered. A. C. Herb.: Rutland 784.

ACER RUBRUM L. Red, Swamp or Soft Maple. Found only in the upper Red River country. Can hardly be considered as established in the state. It is a very valuable tree for wood and lumber. It is grown quite successfully as a shade tree in the Red River Valley. A. C. Herb.: Fargo 775.

NEGUNDO ACEROIDES Moench. *Acer Negundo* L. Box Elder. Ash-leaved Maple. Found everywhere in wooded districts of the state. An especially valued tree in this region because hardy and a good wood producer. Extensively cultivated for shade and ornamental purposes. The older tree claims now furnish much wood for fuel. A. C. Herb.: Fargo 121, Rutland, Devil's Lake, Medora, Wahpeton. Univ. Herb.: Grand Forks.

ANACARDIACEAE. SUMAC FAMILY.

RHUS GLABRA L. Smooth or Scarlet Sumac. A shrub two to twenty feet high. Found along the rivers and in shrubbery throughout the state. It thrives well in dry places and has quite ornamental foliage for shrubbery effects in gardens. The fruit of the plant constitutes an official drug. U. S. P. A. C. Herb.: Fargo 122.

RHUS TOXICODENDRON L. *Rhus radicans* L. Poison, Climbing, or Three-leaved Ivy. Poison Oak. Climath. A low creeping or climbing shrub found throughout the state in woodlands or wild shrubbery. Contact with this plant causes a most disagreeable poisoning of the skin or rash now know to be due to a volatile oil, a natural product of the plant. The leaves of the plant are used as an official drug. See U. S. P. A. C. Herb.: Devil's Lake 123, Fargo.

RHUS CANADENSIS Marsh. *Rhus aromatica* Ait. Fragrant or Sweet-scented Sumac. Larger leaved and more densely fruited than the following. Univ. Herb.: Minot.

RHUS CANADENSIS TRILOBATA Gray. *Rhus trilobata* Nutt. Ill-scented Sumac. Skunk Bush. Found in the Bad Lands of the western part of the state. A scraggly ill-smelling shrub. A. C. Herb.: Medora 124.

POLYGALACEAE. MILKWORT FAMILY.

Polygala Senega L. Seneca Snakeroot. Found quite generally throughout the wooded ridges of the state. Not abundant. The plant has value as an official drug, and is becoming rare. A. C. Herb.: Lisbon 125, Rolla 126. Univ. Herb.: Bottineau.

Polygala alba Nutt. White Senega. False Senega. Abundant throughout the prairie ridges of the state. Sold as a substitute for *P. Senega.* Cannot say as to its value medicinally. A. C. Herb.: Jamestown 127, Ft. Buford, Medora, Bismarck, Rutland. Univ. Herb.: Grand Forks.

Polygala verticillata L. Whorled-leaved Milkwort. Common to the prairie regions of the state. A. C. Herb.: Bismarck 129, Englevale 130. Univ. Herb.: Grand Forks.

LEGUMINOSAE. PULSE FAMILY. PEA FAMILY OR BEAN FAMILY.

This family is also known under the names Phaseolaceae and Papilionaceae. The family contains many of the most useful food and forage plants, hence the native ones are of much interest. The plants of this group are also able to collect and make use of the free nitrogen of the air, a quality not commonly possessed by other plants. When they decay they thus increase the nitrogen content of the soil. For this last reason there are very few of these plants which should be treated as weeds.

Thermopsis rhombifolia Nutt. Prairie Thermopsis. A. C. Herb.: White Earth 1265. Coll., Haigh.

Lupinus argenteus Pursh. Coult. Man. Silver Lupine. Perennial, coarse branching. A. C. Herb.: State line west of Medora on N. P. Railway 131, Cannon Ball.

Lupinus pusillus Pursh. Low Lupine. An annual upon the open dry prairies. A. C. Herb.: Medora 132. Univ. Herb.: Grand Forks.

Trifolium pratense L. Red, Purple, or Common Field Clover. Honeysuckle Clover. Throughout eastern U. S. Naturalized from Europe. Does not gain a foothold rapidly in prairie regions. Gives a good fodder crop in the Red River Valley and other regions of the state which are sufficiently watered throughout the year. A. C. Herb.: Fargo 133, Page City, Edgeley.

TRIFOLIUM REPENS L. White Clover. Shamrock. Pastures and waste places. Spreads in this state as a wild plant in all places sufficiently moist. It is quite generally used in the development of lawns and for that purpose is about as effectual as a pure blue grass sod. As it starts late in the spring it does not give an early lawn growth. A. C. Herb.: Fargo 137, Valley City, Neche, Univ. Herb.: Grand Forks.

TRIFOLIUM HYBRIDUM L. Alsike Clover. Alsatian Clover. Swedish Clover. This plant is much like white clover only with rose-tinted flowers. Escaped from cultivation, in a few waste places. A. C. Herb.: Valley City 135, Fargo. Univ. Herb.: Grand Forks.

TRIFOLIUM INCARNATUM L. Crimson Clover. Carnation Clover. Italian Clover. Introduced by cultivation. A. C. Herb.: Fargo 752.

MELILOTUS ALBA Desv. White Melilot. White Sweet-clover. A scattering weed, too coarse for forage. Introduced. A fine plant for bees. A. C. Herb.: Fargo 139.

MELILOTUS OFFICINALIS Willd. *Melilotus officinalis* (L.) Lam. Yellow Melilot. This plant, though a legume, is nearly valueless as a forage plant. Its chief value seems to be the production of honey. It is being introduced in different portions of the state. A. C. Herb.: Page 1236.

MEDICAGO SATIVA L. Lucerne. Alfalfa. Purple Medic. Brazilian Clover. Snail Clover. Spanish Trefoil. Introduced. A perennial fodder plant. A. C. Herb.: Fargo 140.

HOSACKIA PURSHIANA Benth. *Lotus Americanus* (Nutt.) Bisch. Prairie Bird's Foot. Trefoil. Throughout the prairies of the state. An annual and a heavy seed produced. A. C. Herb.: Sykeston 141, Devil's Lake 142, Mandan 143, Medora, Ft. Totten, Tower, Towner, Lisbon, LaMoure. Univ. Herb.: Ft. Totten.

PSORALEA TENUIFLORA Pursh. Few-flowered Psoralea. Distributed throughout the state. A perennial herb. A. C. Herb.: Medora 144. Univ. Herb.: Ft. Totten.

PSORALEA ARGOPHYLLA Pursh. Silver-leaf Psoralea. Everywhere on the open prairie sod. The foliage of this plant would make it a valuable ornamental herb. A. C. Herb.: Towner 145, Bismarck 146, Medora. Bottineau, Valley City, Fargo, Hope, Lisbon. Univ. Herb.: Edinburg.

PSORALEA ESCULENTA Pursh. Pomme Blanche. Pomme de Prairie. Prairie Turnip. Indian Bread-root. Evenly distributed throughout the prairie sod of the state. The deep placed root of this plant is shaped much like a large sweet potato. It is edible and possessed of a high starch content. It is possible that it could be highly improved and made of value through culture. A. C. Herb.: Dawson 147, Fargo 148, Devil's Lake, Valley City, Lisbon, Medora. Univ. Herb.: Grand Forks.

AMORPHA CANESCENS Nutt. *Amorpha canescens* Pursh. False Indigo. Lead Plant. Shoe-strings. A bushy shrub one to three feet high. Found throughout the prairies of the state. Its foliage and flowers silvery and ornamental makes it a valuable plant for lawn shrubbery in dry places. A. C. Herb.: Hope 149, Medora 150, Jamestown, Fargo, Bismarck, Harlem, Davenport, Hillsboro. Univ. Herb.: Larimore.

AMORPHA MICROPHYLLA Pursh. *Amorpha nana* Nutt. Fragrant False Indigo. Shrub as in last but smaller. A. C. Herb.: Valley City 151, Devil's Lake.

AMORPHA FRUTICOSA L. False or Bastard Indigo. This plant is a shrub from three to twenty feet high. It is to be found along most of the streams of the state. Under conditions of sufficient soil moisture the plant has considerable ornamental value. A. C. Herb.: Rutland 153, Fargo 154, Bismarck.

DALEA ALOPECUROIDES Willd. *Parosela Dalea* (L.) Britt. Pink Parosela. An annual herb. A. C. Herb.: Lisbon 733. Coll., Fieldstad.

PETALOSTEMON VIOLACEUS Michx. *Kuhnistera purpurea* (Vent.) MacM. Violet Prairie Clover. Everywhere common on the prairies of the state. A. C. Herb.: Sykeston 155, Hillsboro 156, Hope, Bismarck, Medora, Harlem. Univ. Herb.: Larimore.

PETALOSTEMON CANDIDUS Michx. *Kuhnistera candida* (Willd.) Kuntze. White Prairie-clover. This and the violet flowered one above are characteristic plants of the prairies of the state, seen everywhere. They seem harmless and of little value aside from their nitrogen gathering abilities. A. C. Herb.: Medora 157, Hope 158, Fargo, Towner, Page, Bismarck, Harlem, Bottineau. Univ. Herb.: Larimore.

PETALOSTEMON VILLOSUS Nutt. *Kuhnistera villosa* (Nutt.) Kuntze. Hairy Prairie-clover. Throughout the state, prairie regions. A. C. Herb.: Milnor 1118. Coll., Fieldstad. Univ. Herb.: Rugby.

Petalostemon multiflorus Nutt. *Kuhnistera multiflora* (Nutt.) Heller. Round-headed Prairie Clover. Univ. Herb.: Larimore.

Astragalus caryocarpus Ker. *Astragalus crassiscarpus* Nutt. Ground Plum. Buffalo Bean. Buffalo Pea. Common throughout the prairies of the state, especially upon the driest ridges. The fruit of this plant is quite large and edible. Cultivation might make it a valuable plant. It is greedily eaten by stock, so it is fast disappearing upon ranges. A. C. Herb.: Grand Rapids 159. Rutland, Hope.

Astragalus Plattensis Nutt. Coult. Man. Platte Milk Vetch. A. C. Herb.: White Earth 1256. Coll., Haigh.

Astragalus Canadensis L. *Astragalus Carolinianus* L. Carolina Milk Vetch. Along streams and highway ditches. A strong rugged herbaceous perennial. A. C. Herb.: Jamestown 160, Fargo 161, LaMoure, Davenport, Sykeston, Lake Metigoshe, Rutland, Medora. Univ. Herb.: Grand Forks.

Astragalus adsurgens Pall. Ascending Milk Vetch. Throughout the state. A. C. Herb.: Medora 162, Valley City 163, Lisbon, Neche. Univ. Herb.: Grand Forks.

Astragalus hypoglottis L. Purple Milk Vetch. Cock's-head. A. C. Herb.: Fargo 1193, Univ. Herb.: Langdon.

Astragalus racemosus Pursh.. Racemose Milk Vetch. Throughout the state. A. C. Herb.: Medora 171, Jamestown, Church's Ferry. Hope, Mouse River.

Astragalus gracilis Nutt. Slender Milk Vetch. Univ. Herb.: Grand Forks.

Astragalus lotiflorus Hook. Low Milk Vetch. A. C. Herb.: Medora 165.

Astragalus Missouriensis Nutt. Missouri Milk Vetch. A. C. Herb.: Medora 166, Devil's Lake.

Astragalus flexuosus Dougl. Flexile Milk Vetch. A. C. Herb.: Valley City 170, Buffalo 1127.

Atragalus bisulacatus A. Gray. Coult. Man. Two-grooved Milk Vetch. A. C. Herb.: Devil's Lake 164.

ASTRAGALUS PECTINATUS Dougl. Coult. Man. Narrow-leaved Milk Vetch. A. C. Herb.: White Earth 1272, Medora 169.

ASTRAGALUS MULTIFLORUS Gray. *Homalobus tenellus* (Pursh) Britt. Loose-flowered Milk Vetch. A. C. Herb.: Medora 167, Devil's Lake 168.

ASTRAGALUS CAESPITOSUS Gray. Coult. Man. *Homalobus caespitosus* Nutt. Tufted Milk Vetch. Found in Bad Lands upon bare buttes. A. C. Herb.: Medora 173.

ASTRAGALUS KENTROPHYTA Gray. Coult. Man. *Homalobus montanus* (Nutt.) Britt. A. C. Herb.: Medora 1042.

ASTRAGALUS TRIPHYLLUS Pursh. Coult. Man. *Orophaca caespitosa* (Nutt.) Britt. A. C. Herb.: White Earth 1263. Coll., Haigh.

OXYTROPIS LAMBERTI Pursh. *Spiesia Lamberti* (Pursh) Kuntze. Stemless Loco Weed. Crazy Weed. Colorado Loco Vetch. This plant differs in appearance from the true or woolly loco chiefly in its smaller size. Because of its mal-nutritive qualities it is very prejudicial to stock-raising, if it is sufficiently abundant. A. C. Herb.: Medora 176, Valley City, Church's Ferry, Jamestown, Rutland. Univ. Herb.: Grand Forks.

OXYTROPIS SPLENDENS Dougl. *Spiesia splendens* (Dougl.) Kuntze. Showy Oxytrope. A. C. Herb.: Church's Ferry 174, Univ. Herb.: Grand Forks.

GLYCYRRHIZA LEPIDOTA Nutt. *Glycyrrhiza lepidota* Pursh. Wild Licorice. A rough herb from perennial root of no known value. A. C. Herb.: Harlem 177, Fargo 178, Valley City, Hillsboro, Lisbon, Bottineau, Medora. Univ. Herb.: Grand Forks.

DESMODIUM DILLENII Darl. *Meibomia Dillenii* (Darl.) Kuntze. Dillen's Tick Trefoil. Found in the edges of thickets. Especially troublesome to those who raise sheep for wool. The jointed pods adhere to wool, matting it as do burrs. A. C. Herb.: Fargo 180.

DESMODIUM CANADENSIS DC. *Meibomia Canadensis* (L.) Kuntze. More abundant than last species. A. C. Herb.: Devil's Lake 181, Wild Rice, Fargo.

VICIA CAROLINIANA Walt. Carolina Vetch. Woodlands, climbing upon shrubbery. Univ. Herb.: Grand Forks.

VICIA AMERICANA Muhl. American Vetch. Pea Vine. Perennial from root. It seems to be of considerable forage value. Trailing over the ground in scattering clumps in low moist places. A. C. Herb.: Neche 183, Valley City, Lisbon, Fargo, Kirk, Towner, Bathgate, Medora, Jamestown, Rolla. Univ. Herb.: Grand Forks.

VICIA AMERICANA LINEARIS Wats. *Vicia linearis* (Nutt.) Greene. Narrow-leaved American Vtech. Found everywhere with last species. Characters similar. A. C. Herb.: Rutland 184, Rolla, Church's Ferry. Univ. Herb.: Grand Forks.

VICIA AMERICANA TRUNCATA Brewer. Coult. Man. A. C. Herb.: Dickinson 1172.

LATHYRUS OCHROLEUCUS Hook. Cream-colored Vetchling. Along the banks of streams in woodlands. Eaten by stock. Perennial from root. A. C. Herb.: Rolla 185, Neche 186.

LATHYRUS VENOSUS Muhl. Veiny Pea. A stout climber from perennial roots in woodlands. Relished by cattle. A. C. Herb.: Lake Metigoshe 187, Neche 188, Ft. Totten, Rolla, Fargo, Valley City. Univ. Herb.: Grand Forks.

LATHYRUS PALUSTRIS L. Marsh Vetchling. This plant thrives in marshy lands amid grasses, and shows considerable forage value. A. C. Herb.: Rolla 189, Valley City, Fargo, Lisbon. Univ. Herb.: Devil's Lake.

Note that the different species of Lathyrus closely approach the cultivated pea in habit and forage qualities. Our native species are perennial, and all of them show capabilities of making a heavy growth. Under cultivation, it is possible that one or more of them might become of value.

AMPHICARPAEA MONOICA Nutt. *Falcata comosa* (L.) Kuntze. Wild Peanut. Hog Peanut. Found in thickets. A. C. Herb.: Wild Rice 191. Univ. Herb.: Grand Forks.

ROSACEAE. ROSE FAMILY.

PRUNUS AMERICANA Marshall. Wild, Yellow or Red Plum. Found in thickets throughout the state. It is the parent of many varieties of cultivated plums. The fruit of this species is quite variable, and in many cases thin-skinned and of fine quality. It is one of the native fruits which will pay well under proper culture. Handled as a shrub, the plant is a good one for ornamental purposes. A. C. Herb.: Lisbon 192, Rutland 193, Wahpeton, Fargo, Turtle Mts.

PRUNUS NIGRA Ait. Britt. & Br. Fl. Canada Plum. This plum varies in character from a shrub to a tree twenty to thirty feet high. The leaves are thinner than in the last species and duller in luster. The fruit is similar to the common red plum. A. C. Herb.: Turtle Mts. 194.

PRUNUS BESSEYI Bailey. Britt. & Br. Fl. Bessey's Sand Cherry. Similar to *P. pumila,* but having larger more bitter fruit. A. C. Herb.: New England City 1150. Coll., Perrine. Milnor 1105. Coll., Fieldstad.

PRUNUS PENNSYLVANICA L. f. Wild Red Cherry. Pin Cherry. Pigeon Cherry. A slender tree rarely attaining a diameter of ten inches. Leaves rather dark green and shining, fruit bright red with little flesh and intensely astringent, readily eaten by birds. A. C. Herb.: Lisbon 1170, Ft. Totten, Turtle Mts.

PRUNUS VIRGINIANA L. Choke Cherry. its purple fruit is very astringent. A. C. Herb.: Fargo 195, Valley City 1090, Mandan, Medora, Rolla, Jamestown.

PRUNUS DEMISSA Walp. Western Wild Cherry. The plant is similar to the last species, but the fruit is edible and gives promise of something valuable when placed under cultivation. A. C. Herb.: Fargo 757, Devil's Lake 1173.

SPIRAEA SALICIFOLIA L. Willow-leaved Spiraea. Meadow-sweet. Quaker Lady. Found in moist soils throughout the prairies of the state. This plant when properly handled makes beautiful effects in ornamental shrubbery for lawns. A. C. Herb.: Rolla 197, Hope, Lake Metigoshe, Lisbon, Page, Neche, Fargo. Univ. Herb.: Grand Forks.

RUBUS TRIFLORUS Richards. *Rubus Americanus* (Pers.) Britt. Dwarf Raspberry. A small annual trailing plant found in swampy places. A. C. Herb.: Ft. Totten 199, Turtle Mts.

RUBUS STRIGOSUS Michx. Wild Red Raspberry. This is the original of the various red raspberries of cultivation. Found in undergrowths throughout the state. A. C. Herb.: Fargo 201, Neche, Lake Metigoshe, Rolla.

GEUM ALBUM Gmelin. *Geum Canadense* Jacq. White Avens.

A hairy perennial herb. A. C. Herb.: Jamestown 204, Fargo, Valley City. Univ. Herb.: Grand Forks.

GEUM MACROPHYLLUM Willd. Large-leaved Avens. A rough-leaved herb of a swampy habit. A. C. Herb.: Rolla 206, Valley City, Neche, Fargo.

GEUM STRICTUM Ait. Yellow Avens. A. C. Herb.: Rolla 207, Neche, Fargo. Univ. Herb.: Grand Forks.

GEUM TRIFLORUM Pursh. *Geum ciliatum* Pursh. Indian Paint-Brush. Long-plumed Purple Avens. This is one of the characteristic plants of the open prairies of the state. If it may not be said to be beautiful, it is quite unique in its purple head dress, and solitary habit. It is worthy of study as an ornamental plant. A. C. Herb.: Lisbon 208, Hope 209, Fargo, Valley City, Oakes. Univ. Herb.: Grand Forks.

FRAGARIA VIRGINIANA Mill. *Fragaria Virginiana* Duch. Virginia Strawberry. Scarlet Strawberry. Found throughout the state. A. C. Herb.: Fargo 1175. Univ. Herb.: Langdon.

FRAGARIA VESCA L. *Fragaria Americana* (Port.) Britt. European Wood Strawberry. Found throughout the wooded areas of the state. A. C. Herb.: Fargo 210.

POTENTILLA ARGUTA Pursh. Glandular Cinquefoil. Five-finger. A. C. Herb.: Sykeston 211, Fargo, Leeds, Tower City, Davenport, LaMoure, Valley City, Lisbon. Univ. Herb.: Grand Forks.

POTENTILLA NORVEGICA L. *Potentilla Monspeliensis* L. Rough Cinquefoil. This plant is a rough annual, sometimes biennial. It grows freely upon cultivated ground and becomes quite a weed in low wet spots. A. C. Herb.: Jamestown 213, Tower, Medora, Lake Metigoshe, Harlem, Lisbon, Valley City, Sykeston, Fargo.

POTENTILLA RIVALIS MILLEGRANA Wats. *Potentilla leucocarpa* Rydb. A. C. Herb.: Valley City 1368. Coll., Perrine.

POTENTILLA SUPINA L. *Potentilla paradoxa* Nutt. A. C. Herb.: Leeds 216.

POTENTILLA SUPINA NICOLLETII Wats. *Potentilla Nicolletii* (Wats.) Sheldon. Nicollet's Cinquefoil. A. C. Herb.: Leeds 215.

POTENTILLA PENNSYLVANICA L. Prairie Cinquefoil. A. C. Herb.: Willow City 219, Sykeston, Jamestown, Lisbon, Neche, Tower, Rolla, Fargo.

POTENTILLA PENNSYLVANICA STRIGOSA Lehm. A. C. Herb.: Valley City 217, Leeds. Univ. Herb.: Grand Forks.

Potentilla Hippiana Lehm. Woolly Cinquefoil. Univ. Herb.: Grand Forks.

Potentilla argentea L. Silver Cinquefoil. A. C. Herb.: Rolla 1358. Coll., Perrine.

Potentilla fruticosa L. Shrubby Cinquefoil. Hardhack. Prairie Brush. This shrub could be made of use as an ornament in lawns, but is a troublesome weed, in the way of cultivation. A. C. Herb.: Medora 220.

Potentilla Anserina L. Silver Weed. Goose Tansy. Everywhere throughout the state in wet places. A bad weed. Could be made use of as an ornamental plant. A. C. Herb.: Medora 221, Leeds 222, Page, Hope, Lake Metigoshe, Fargo, Oakes, Rolla, Rutland, Jamestown, Bathgate, Valley City. Univ. Herb.: Grand Forks.

Chamaerhodos erecta Bunge. Coult. Man. A. C. Herb.: Kidder Co. 1347. Coll., Perrine.

Agrimonia Eupatoria L. *Agrimonia hirsuta* (Muhl.) Bicknell. Tall Hairy Agrimonia. This plant, though not abundant here, is a troublesome weed because of its bur-like fruits which adhere to clothing and to the wool and hair of animals. A. C. Herb.: Ft. Totten 223, Bathgate, Dunseith, Neche. Univ. Herb.: Grand Forks.

Rosa Engelmanni Wats. *Rosa acicularis* Lindl. Prickly Rose. A. C. Herb.: Fargo 231, Turtle Mts.

Rosa blanda Ait. Smooth Rose. Meadow Rose. This and the next species are the common roses of the prairies. From the standpoint of cultivation and wheat culture the wild rose is one of the worst weeds. Yet it is not without its virtue. Its deep-going roots must be of much value in opening up the subsoil and leavening the soil of idle land. When put under cultivation in the garden it furnishes a beautiful shrub in the flowering season. A. C. Herb.: Minot 225, Lake Metigoshe, Neche, Rutland, Fargo, Lisbon, Rolla, Jamestown. Univ. Herb.: Grand Forks.

Rosa Arkansana Porter. Arkansas Rose. This is more common than the last, everywhere in the state. It is distinguished from *Rosa blanda* chiefly in being more prickly. A. C. Herb.: Fargo 227, Bismarck, Tower, Bathgate, Church's Ferry, Valley City, Leeds, Lisbon. Univ. Herb.: Grand Forks.

Rosa Carolina L. Swamp Rose. A. C. Herb.: Medora 230.

NOTE.—It is very difficult to determine the roses by the notes given in present manuals. There are roses in the A. C. collection which fit one description about as well as another. It is evident that the different species are very variable according to environment, and that present descriptions are not sufficiently accurate.

PYRUS ARBUTIFOLIA L. f. *Aronia arbutifolia* (L.) Ell. Red Choke-berry. Common in shrubbery along river banks. A small shrub characteristically like an apple in appearance. It produces an abundance of small flowers and could be developed as ornamental shrubbery. A. C. Herb.: Fargo 232.

CRATAEGUS COCCINEA L. Hawthorn. Thornapple. Scarlet Hawthorn. Scarlet Haw. A shrub or small thorny tree along river woodlands. The wood is hard and of good quality and the fruit is edible, but the tree is to be valued most in this state for its fine ornamental effect in lawns. It is possible to make a good hedge of this plant, but the cost is always far in excess of that for a good fence. A. C. Herb.: Fargo 758, Wahpeton 233.

CRATAEGUS PUNCTATA Jacq. Large-fruited Thorn. A tree much as the last, with fruit of a larger finer quality and a larger flower. A. C. Herb.: Valley City 1357. Univ. Herb.: Grand Forks.

AMELANCHIER ALNIFOLIA Nutt. Northwestern June-berry. Service-berry. This shrub makes a growth from six to ten feet. Bears a sweet edible berry, and may be made use of as an ornamental shrub. Its foliage and branching is particularly fitted for this purpose. Found in thickets and along streams everywhere. A. C. Herb: Rolla 234, Fargo, Valley City, Lisbon, Devil's Lake, Medora.

SAXIFRAGACEAE. SAXIFRAGE FAMILY.

HEUCHERA HISPIDA Pursh. Rough Heuchera. Alum Root. A. C. Herb.: Fargo 235, Lisbon, Rutland, Verona, Valley City, Page. Univ. Herb.: Grand Forks.

PARNASSIA PALUSTRIS L. Marsh-grass. Northern Grass-of-Parnassus. A pretty perennial bog or marsh herb. A. C. Herb.: Lake Metigoshe 237, Englevale.

PARNASSIA CAROLINIANA Michx. Carolina Grass-of-Parnassus. A. C. Herb.: Towner 238. Univ. Herb.: Bottineau.

RIBES GRACILE Michx. Missouri Gooseberry. This plant is much like the next, except this shrub is very prickly. A. C. Herb.: Sheyenne River, Fargo 768, Devil's Lake 240.

RIBES OXYACANTHOIDES L. Wild Gooseberry. Smooth Gooseberry. Northern Gooseberry. This plant produces a large quantity of long, smooth, well flavored berries. It is worthy of cultivation. In woodlands throughout the state. A. C. Herb.: Fargo 239, Valley City.

RIBES FLORIDUM L'Her. Wild Black Currant. This bush bears an abundance of fruit and flowers. The fruit, however, because of peculiar taste and musk-like odor, is of slight value. The shrub is valuable in this latitude for foliage effects. It is distributed throughout the wooded banks of the rivers of the state. A. C. Herb.: Fargo 756, Neche 241, Wahpeton.

RIBES RUBRUM SUBGLANDULOSUM Maxim. *Ribes rubrum* L. Red Currant. Found native throughout the bogs and spring lands of the Turtle Mts. A. C. Herb.: Northwest of Bottineau 243.

NOTE.—The fact that all these gooseberries and currants are found native to the state, perfectly hardy and markedly productive should be encouraging to those who wish to cultivate such fruits.

CRASSULACEAE. ORPINE FAMILY.

PENTHORUM SEDOIDES L. Ditch Stonecrop. Virginia Stonecrop. A small, rather weak, ditch weed. A. C. Herb.: Wild Rice 244, Fargo.

HALORAGEAE. WATER-MILFOIL FAMILY.

MYRIOPHYLLUM SPICATUM L. Spiked Water-Milfoil. One of several species of filiform-leaved, aquatic plants which probably will be found in the lakes and ponds of the state. Masses of this plant furnish a fine feeding and breeding ground for fish. A. C. Herb.: LaMoure 246, Fargo. Univ. Herb.: Bottineau.

MYRIOPHYLLUM HETEROPHYLLUM Michx. Various-leaved Water-Milfoil. Similar in habit to the above. A. C. Herb.: Svea 1137. Coll., Fieldstad.

HIPPURIS VULGARIS L. Bottle Brush. Joint-weed. Perennial aquatic. Univ. Herb.: Bottineau.

CALLITRICHE HETEROPHYLLA. Larger Water-Starwort. A. C. Herb.: Fargo 1331.

ONAGRACEAE. EVENING PRIMROSE FAMILY.

EPILOBIUM ANGUSTIFOLIUM L. *Chamaenerion angustifolium* (L.) Scop. Great Willow-herb. Fire-weed. A. C. Herb.: Rolla 247, Tower City, Lake Metigoshe, Neche, Sykeston. Univ. Herb.: Grand Forks.

EPILOBIUM LINEARE Muhl. Linear-leaved Willow-herb. A. C. Herb.: Ft. Totten 248.

EPILOBIUM COLORATUM Muhl. Purple-leaved Willow-herb. A. C. Herb.: Englevale 249, Lisbon, Lake Metigoshe. Univ. Herb.: Grand Forks.

EPILOBIUM ADENOCAULON Haussk. Northern Willow-herb. A. C. Herb.: Lisbon 1168. Coll., Fieldstad.

OENOTHERA BIENNIS L. *Onagra biennis* (L.) Scop. Common Evening-Primrose. Golden-Candlestick. A rank growing plant often found in wheat fields in this region. As it is a heavy seed producer and a lover of poorly cultivated areas, it should be looked upon as a weed. It produces seed the second year. A. C. Herb.: Medora 251, Leeds 252, Englevale, Dickinson, Jamestown, Williston, Devil's Lake, Tower, Argusville. Univ. Herb.: Grand Forks.

OENOTHERA ALBICAULIS Nutt. *Anogra pallida* (Lindl.) Britt. White-stemmed Evening Primrose. General throughout the prairies of the state. Much the same in habit as last. A. C. Herb.: Jamestown 253, Leeds 254, Dickinson, Rolla, Sykeston, Towner. Univ. Herb.: Willow City.

OENOTHERA PINNATIFIDA Nutt. Coult. Man. *Anogra albicaulis* (Pursh) Britt. Prairie Evening Primrose. Found in western parts of the state. A. C. Herb.: Ft. Buford 255, Dickinson.

OENOTHERA CAESPITOSA Nutt. Coult. Man. *Pachylophus caespitosa* (Nutt.) Raimann. Scapose Primrose. This is a very large and showy species without any aerial stem. It would do fine service in ornamental gardens. A. C. Herb.: Ft. Buford 256.

OENOTHERA SERRULATA Nutt. *Meriolix serrulata* (Nutt.) Walp. Tooth-leaved Primrose. This is a rather pretty, aparently harmless, species common to the prairies of the state. A. C. Herb.: Valley City 257, Church's Ferry 258, Mandan, Page, Sykeston, Lisbon, Jamestown, Hope, Fargo, Bismarck. Univ. Herb.: Grand Forks.

GAURA COCCINEA Nutt. *Gaura coccinea* Pursh. Scarlet Gaura. A. C. Herb.: Towner 1175, Sykeston, LaMoure, Rutland, Valley City, Fargo, Lisbon, Medora, Englevale. Univ. Herb.: Grand Forks.

CIRCAEA LUTETIANA L. Enchanter's Nightshade. In woodlands and thickets. A. C. Herb.: Wild Rice 260, Neche 261. Univ. Herb.: Grand Forks.

LOASACEAE. LOASA FAMILY.

MENTZELLA ORNATA T. & G. *Mentzelia decapetala* (Pursh) U. & G. Showy Mentzelia. A rather showy, poppy-like appearing plant, possibly of similar ornamental worth, but as it has a very weedy aspect, it is perhaps best that it should be left to its native foot hills. A. C. Herb.: Medora 262, Bismarck.

CUCURBITACEAE. GOURD FAMILY.

SICYOS ANGULATUS L. One-seed Bur-cucumber. Star Cucumber. Nimble Kate. A climbing annual which may be used to advantage in arbors for shading purposes. Univ. Herb.: Devil's Lake.

ECHINOCYSTIS LOBATA T. & G. *Micrampelis lobata* (Michx.) Greene. Wild Balsam Apple. Prickly Cucumber, This plant is found in the rich alluvial soils of river banks. It is a great climber and is often made use of for shade and foliage. Its rank growth and profuse seed production, however, makes it a difficult weed to eradicate when once planted in a garden. A. C. Herb.: Minot 264, Bismarck, Mandan. Univ. Herb.: Grand Forks.

CACTACEAE. CACTUS FAMILY.

MAMILLARIA VIVIPARA Haw. *Cactus viviparus* Nutt. Purple Cactus. The fruit of this cactus is edible giving a pleasing acid flavor when ripe. It is found throughout the western prairie regions of the state. A. C. Herb.: Valley City 1065. Coll., Perrine.

OPUNTIA MISSOURIENSIS DC. *Opuntia polyacantha* Haw. Many-spined Opuntia. A. C. Herb.: Medora 266.

OPUNTIA FRAGILIS Haw. Brittle Opuntia. A. C. Herb.: Svea, Barnes Co. 1313. Coll., Perrine.

UMBELLIFERAE. PARSLEY FAMILY.

DAUCUS CAROTA L. Wild Carrot. This is a biennial of wide distribution not yet common in this state, naturalized from Europe. Elsewhere in many places it is a persistent weed in pasture lands and hay fields. It should be uprooted. This plant is a host for one of the most destructive parasitic diseases of celery, and thus helps to introduce that disease. A. C. Herb.: Ft. Totten 267, Devil's Lake 268.

HERACLEUM LANATUM Michx. Cow Parsnip. A. C. Herb.: Fargo 269.

PASTINACA SATIVA L. Wild Parsnip. This plant is comparatively scarce in the state, but is a rank growing weed in many similar regions. It could become very pernicious in the valley lands of the state. It grows biennially from roots similar to those of the common parsnip. These are said to be poisonous either raw or cooked. The plant also is a natural host for one of the worst celery fungi. The celery interests of the state which are growing so rapidly demand the destruction of this weed wherever found, as the spores of the fungus upon it are always sources of infection for the celery fields. The plants should be cut below the crown before seeding time. A. C. Herb.: Fargo 270.

PEUCEDANUM NUDICAULE Nutt. White-flowered Parsley. Found throughout the prairie regions of the state. A. C. Herb.: Valley City 1170, Ellendale 751. Univ. Herb.: Grand Forks.

PEUCEDANUM VILLOSUM Nutt. Coult. Man. Hairy Parsley. One of the earliest spring plants to bloom. A. C. Herb.: Ward Co. 1255. Coll., Haigh. Univ. Herb.: Grand Forks.

THASPIUM AUREUM Nutt. *Thaspium trifoliatum aureum* (Nutt.) Britt. Purple Meadow-Parsnip. The habits of this plant are much the same as those of the larger sorts of wild parsnips, weedy. Univ. Herb.: Grand Forks.

CRYPTOTAENIA CANADENSIS DC. *Derinaa Candensis* (L.) Kuntze. A. C. Herb.: Fargo 271, Lisbon 1134.

SIUM CICUTAEFÓLIUM Gmelin. Hemlock Water-Parsnip. In swamps, coulees, low meadows and river margins. A plant open to suspicion as a destroyer of cattle. Grows generally throughout the state, often associated with Water Hemlock. It is possible that that plant does all of the poisoning. A. C. Herb.: Fargo 272, Hope, Lisbon, Turtle Mts., Svea..

Berula angustifolia Koch. *Berula erecta* (Huds.) Coville. Cut-leaved Water-Parsnip. A. C. Herb.: Lisbon 1200. Coll., Fieldstad.

Zizia aurea Koch. Early or Golden Meadow Parsnip. Lowland plants found throughout the state. A. C. Herb.: Turtle Mts. 273, Fargo, Jamestown, Lisbon.

Zizia cordata DC. Heart-leaved Alexanders. On open prairie in low spots throughout the state. A. C. Herb.: Verona 275, Sykeston, Page, White Earth.

Carum Carui L. Caraway. Escaped from cultivation in places. A. C. Herb.: Fargo 280, Monango 1148.

Cicuta maculata L. Water Hemlock. Musquash Root. Spotted Beaver Poison. Spotted Parsley. Children's Bane. A swamp plant common throughout the state in low meadow lands, ditches, coulees and along streams. Very poisonous in all its parts. Causes considerable loss of cattle when fed in hay, or when eaten green. See Bulletin 44, N. D. Exp. Sta., and Bulletin 20. Div. Bot., U. S. Dept. Agr. A. C. Herb.: Fargo 277, Hope, Jamestown, Dawson, Power. Univ. Herb.: Grand Forks.

Cicuta bulbifera L. Bulbous Water Hemlock. This plant is as poisonous as the ordinary Water Hemlock, but is not found as common in this state as *Cicuta maculata.* It is distinguished by its narrow linear leaves and by the bulblets borne in the axils of the upper leaves. A. C. Herb.: St. Andrews 1202.

Osmorrhiza longistylis DC. *Washingtonia longistylis* (Torr.) Britt. Smooth Sweet-Cicely. Anise root. Found in shady woodlands along various streams of the state. The roots are edible, giving a pleasant sweet taste and odor of anise. A. C. Herb.: Fargo 278, Valley City 279, Neche, Wahpeton.

Musineon divaricatum Nutt. Coult. Man. A Small fennel-like herb of the open prairie. A. C. Herb.: Valley City 1126. Coll., Fieldstad. Lisbon.

Sanicula Marylandica L. Sanicle. Black Snake-root. A. C. Herb.: Neche 281, Valley City 282, Fargo.

ARALIACEAE. GINSENG FAMILY.

Aralia nudicaulis L. Wild Sarsaparilla. Virginian Sarsaparilla. Small Spikenard. Rabbit-root. A woodland plant said to have medicinal values similar to sarsaparilla. A. C. Herb.: Neche 284, Fargo.

CORNACEAE. DOGWOOD FAMILY.

CORNUS CANADENSIS L. Low or Dwarf Cornel. Bunch-berry. A. C. Herb.: Turtle Mts. 283.

CORNUS SERICEA L. *Cornus Amonum* Mill. Silky, Cornel Kinnikinnik. A native shrub suitable for ornamental work in lawns. Bark sometimes used as an astringent and tonic. A. C. Herb.: Fargo 286.

CORNUS STOLONIFERA Michx. Red-osier Cornel. Dogwood. A very ornamental shrub of good size. It will grow well in quite dry soil, shows a good foliage and a red or purplish bark on the youngest branches and stems. It grows from running underground stems and thus tends to form fine clumps. Found everywhere along streams upon dry knolls. A. C. Herb.: Bismarck 287, Lisbon, Minot, Turtle Mts., Rolla, Valley City. Univ. Herb.: Grand Forks.

CORNUS PANICULATA L'Her. *Cornus candidissima* Marsh. Panicled Dogwood. Cornel. A. C. Herb.: Fargo 289. Univ. Herb.: Grand Forks.

CAPRIFOLIACEAE. HONEYSUCKLE FAMILY.

VIBURNUM OPULUS L. Cranberry-tree. Highbush-cranberry. A shrub four to ten feet high. Fruit similar to cranberries. Said to be the parent of the cultivated snow-ball. Found along the water courses. A. C. Herb.: Lake Metigoshe 290, Neche 291, Bismarck, Jamestown, Rolla. Univ. Herb.: Grand Forks.

VIBURNUM LENTAGO L. Sweet Viburnum. Sheep-berry. Nanny-bush. Black Haw. A small shubby tree found along wooded streams. It bears a small black lenticular fruit, which is edible in autumn and of pleasant flavor. A. C. Herb.: Neche 293, Ft. Totten 294, Lisbon. Univ. Herb.: Grand Forks, Devil's Lake.

SYMPHORICARPOS OCCIDENTALIS Hook. Wolf-berry. Found growing along streams and upon the open prairie. It is a very shrubby plant, which when properly handled furnishes a rather effective bit of shrubbery for a lawn. The berries are ornamental but inedible. A. C. Herb.: Fargo 295, Valley City, Lake Metigoshe, Sykeston, Neche, Lisbon.

Symphoricarpos racemosus pauciflorus Robbins. *Symphoricarpos pauciflorus* (Robbins) Britt. Few-flowered Wolf-berry. Smaller than the above. A. C. Herb.: Lake Metigoshe 297.

Lonicera hirsuta Eaton. Hairy Honeysuckle. A twining shrub. Univ. Herb.: Grand Forks.

Lonicera glauca Hill. *Lonicera dioica* L. Smooth-leaved or glaucous Honeysuckle. Univ. Herb.: Grand Forks.

Lonicera glaucescens Rydb. Britt. & Br. Fl. Douglas' Honeysuckle. Plants of this species are mainly referred to *L. glauca* Hill in Gray's Man. Found generally throughout the wooded areas of the state. It is thus hardy and does well under cultivation. Each of the honeysuckles is suited to ornamental planting. A. C. Herb.: Lake Metigoshe 299, Valley City 300, Jamestown, Lisbon.

RUBIACEAE. MADDER FAMILY.

Houstonia purpurea longifolia Gray. *Houstonia longifolia* Gaertn. Long-leaved Houstonia. Univ. Herb.: Grand Forks.

Galium Mullugo L. Wild Madder. White Bedstraw. Great Hedge Bedstraw. Whip-tongue. A weed introduced from Europe. Univ. Herb.: Grand Forks.

Galium Aparine L. Cleavers. Goose-grass. Cleaverwort. A. C. Herb.: Neche 301.

Galium boreale L. Northern Bedstraw. A small strong perennial herb of general distribution. Might be of use for ornamental purposes if properly handled. A. C. Herb.: Fargo 302, Jamestown, Tower City, Sykeston, Lake Metigoshe, Valley City, Neche. Univ. Herb.: Grand Forks.

Galium trifidum L. Small Bedstraw. Found upon wet and boggy places. A. C. Herb.: Valley City 745. Coll., Perrine.

Galium triflorum Michx. Sweet-scented Bedstraw. A. C. Herb.: Fargo 304, Spiritwood Lake 1055.

COMPOSITAE. COMPOSITE FAMILY. ASTERWORTS. THISTLE FAMILY.

Vernonia fasciculata Michx. Western Iron-weed. A. C. Herb.: Medora 305. Fargo, Hope, Mandan, Harlem, Argusville. Univ. Herb.: Minot.

VERNONIA FASCICULATA var. A form collected at Steele which has ovate leaves. A. C. Herb.: 1323. Coll., Perrine.

EUPATORIUM PURPUREUM L. Joe-Pye Weed. Trumpet-weed. Gravel-root. Tall Boneset. Purple Boneset. A. C. Herb.: Towner 307, Neche, Lake Metigoshe, Bottineau. Univ. Herb.: Bottineau. The roots of the herb have been recognized as an official drug for use in intermittent fevers serving the same purpose as the official drug from *E. perfoliatum.*

EUPATORIUM PERFOLIATUM L. Common Thoroughwort. Indian Sage. Boneset. The leaves are used as an official drug. See U. S. P. A. C. Herb.: Ft. Ransom 1324. Coll.. Perrine.

EUPATORIUM AGERATOIDES L. White Snake-Root. A. C. Herb.: Fargo 1235.

KUHNIA EUPATORIOIDES L. False Boneset. A. C. Herb.: Fargo 310, Lisbon.

LIATRIS PUNCTATA Hook. *Lacinaria punctata* (Hook.) Kuntze. Dotted Button-Snakeroot. Blue Blazing Star. Rattlesnake-master. Gay Feather. Found with the last, larger and more showy. A. C. Herb.: Minot 313, Fargo 314, Towner, Bismarck, Leeds, Englevale, Sykeston. Univ. Herb.: Bottineau.

LIATRIS PYCNOSTACHYA Michx. *Lacinaria pycnostachya* (Michx.) Kuntze. Prairie Button-Snakeroot. A. C. Herb.: Milnor 1178. Coll., Fieldstad.

LIATRIS GRAMINIFOLIA Willd. *Lacinaria cylindracea* (Michx.) Kuntze. Blazing Star. Univ. Herb.: Grand Forks.

GUTIERREZIA EUTHAMIAE T. & G. *Gutierrezia Sarothrae* (Pursh) Britt. A. C. Herb.: Medora 316, Sykeston 317, Bottineau, Mandan, Lake Metigoshe. Univ. Herb.: Dickinson.

GRINDELIA SQUARROSA Dunal. Broad-leaved Gum-plant. Resin Plant. The leaves and flowers constitute an official drug said to be of benefit as curative of catarrh and asthma troubles. Everywhere upon prairie. A. C. Herb.: Bismarck 318, Edgeley, Leeds, Sykeston. Univ. Herb.: Minot.

CHRYSOPSIS VILLOSA Nutt. Hairy Golden Aster. A. C. Herb.: Valley City 320, Medora 321, Devil's Lake, Englevale, Towner, Mandan, Bismarck, Jamestown, Leeds, Hope. Univ. Herb.: Dickinson.

APLOPAPPUS SPINULOSUS DC. *Eriocarpum spinulosum* (Nutt.) Greene. A. C. Herb.: Sykeston 322, Lake Metigoshe, LaMoure, Jamestown, Bismarck, Mandan, Leeds, New England City, Page, Harlem. Univ. Herb.: Grand Forks.

BIGELOVIA GRAVEOLENS Gray. *Chrysothamnus nauseosus* (Pursh) Britt. Fetid Rayless Golden-rod. A. C. Herb.: Medora 324.

SOLIDAGO MISSOURIENSIS Nutt. Missouri Golden-rod. This plant and all of the following Golden-rods are ornamental and hardy perennial herbs growing from the roots each year, very beautiful in their native growths, they may also furnish fine clumps or banks under cultivation, about prairie homes. Much visited by honey-bees. A. C. Herb.: Hope 326, Sykeston, Mandan. Univ. Herb.: Grand Forks.

SOLIDAGO MISSOURIENSIS MONTANA Gray. Coult. Man. Low Missouri Golden-rod. A. C. Herb.: Hope 1177, Devil's Lake.

SOLIDAGO SEROTINA Ait. Late Golden-rod. A. C. Herb.: Sims 328, Towner 329, Bismarck. Univ. Herb.: Bottineau.

SOLIDAGO CANADENSIS L. Canada Golden-rod. Common. A. C. Herb.: Lake Metigoshe 330, Harlem 331, Fargo.

SOLIDAGO NEMORALIS Ait. Field Golden-rod. A. C. Herb.: Towner 332.

SOLIDAGO NEMORALIS INCANA Gray. *Solidago mollis* Bartl. Velvety Golden-rod. A. C. Herb.: Mandan 333, Minot, Leeds, Bottineau.

SOLIDAGO RIGIDA L. Hard or Harsh-leaved Golden-rod. Very common on the native sod. A. C. Herb.: Towner 335, Mandan 336, Neche, Fargo. Univ. Herb.: Minot.

SOLIDAGO LANCEOLATA L. *Euthamia graminifolia* (L.) Nutt. Bushy or Fragrant Golden-rod. A. C. Herb.: Englevale 337, Bottineau, Lake Metigoshe.

BOLTONIA ASTEROIDES L. Aster-like Boltonia. Univ. Herb.: Minot.

BOLTONIA LATISQUAMA Gray. Broad-scaled Boltonia. A. C. Herb.: Fargo 338, Harlem, Lisbon, Valley City.

ASTER CAMPESTRIS Nutt. Coult. Man. A. C. Herb.: Medora 339.

Aster oblongifolius Nutt. Aromatic Aster. A. C. Herb.: Minot 340, Mandan, Medora. Univ. Herb.: Grand Forks.

Aster Novae-Angliae L. New England Aster. This is perhaps one of the largest, most sturdy and beautiful of the asters. We have found that it lends itself readily to transplanting, and may be used to great advantage in the construction of summer foliage banks, hedges and clumps for ornamentation. Its autumn flowers are profuse, large and rich in color. The asters are perennial, shrub-like herbs and almost any one of them, as in the case of this species, may be used to beautify any lawn or country home. The asters furnish fine foliage and flowers of practically all shades from white to blue. When once appreciated, they will not be overlooked, and they will furnish the one who cares for them a wealth of summer and late autumn flowers. A. C. Herb.: Towner 342, Lake Metigoshe, Fargo.

Aster azureus Lindl. Sky-blue Aster. Univ. Herb.: Grand Forks.

Aster sagittifolius Willd. Arrow-leaved Aster. A. C. Herb.: Fargo 1369.

Aster Drummondii Lindl. Drummond's Aster. A. C. Herb.: Neche 1120, Fargo 1237.

Aster laevis L. Smooth Aster. A species more common than the New England Aster and about equally desirable. A. C. Herb.: Towner 344, Medora, Bismarck, Lake Metigoshe, Bottineau, Fargo. Univ. Herb.: Larimore.

Aster ericoides L. White Heath Aster. Frost-weed Aster. Farewell Summer. Late Aster. Univ. Herb.: Grand Forks.

Aster multiflorus Ait. White Wreath Aster. Many flowered Aster. Dense-flowered Aster. Fall Flower. A small bushy, autumn flowering, white aster, having its very perfect flowering heads massed in beautiful wreath-like clusters upon slender branches, very ornamental. A. C. Herb.: Englevale 346, Fargo, Bismarck, Towner, Leeds, Sykeston, Edgeley. Univ. Herb.: Minot.

Aster diffusus Ait. *Aster lateriflorus* (L.) Britt. Starved Aster. Calico Aster. A. C. Herb.: Fargo 1051.

Aster commutatus T. & G. Coult. Man. *Aster incanopilosus* (Lindl.) Sheldon. A. C. Herb.: Minot 348.

Aster paniculatus Lam. Tall White or Panicled Aster. A. C. Herb.: Fargo 1052.

Aster junceus Ait. Rush Aster. A. C. Herb.: Lisbon 1115. Coll., Fieldstad.

Aster longifolius Lam. Long-leaved Aster. Univ. Herb.: Grand Forks.

Aster puniceus L. Red-stalked or Purple-stem Aster. A. C. Herb.: Svea 1061. Coll., Fieldstad.

Aster umbellatus Mill. *Doellingeria umbellata* (Mill.) Nees. Tall Flat-top White Aster. Not common. A. C. Herb.: Lake Metigoshe 325.

Aster foliaceus Lindl. Leafy-bracted Aster. A. C. Herb.: Leeds 350, Minot 351.

Aster adscendens Lindl. Western Aster. A. C. Herb.: Englevale 352.

Aster ptarmicoides T. & G. Upland White Aster. A. C. Herb.: Fargo 353, Medora, Towner, Harlem, Bottineau, Hope, Jamestown, Minot. Univ. Herb.: Bottineau.

Aster angustus T. & G. *Brachyactis angustus* (Lindl.) Britt. Rayless Aster. A. C. Herb.: Fargo 1050.

Erigeron Canadensis L. *Leptilon Canadense* (L.) Britt. Horse-weed. Canada Flea-bane. Butter-weed. Sneeze-weed. Colt's-tail. A weed common in meadows and pasture land. The plant furnishes the drug known as Oil of Erigeron. A. C. Herb.: Harlem 356, Leeds 357, Bismarck, Sims, Sykeston, Fargo. Univ. Herb.: Minot.

Erigeron pumilus Nutt. Coult. Man. A. C. Herb.: Medora 355.

Erigeron caespitosus Nutt. Coult. Man. Tufted Erigeron. A. C. Herb.: Mouse River 1269. Coll., Haigh. Steele. Coll., Perrine.

Erigeron annuus Pers. Sweet Scabious. Daisy Fleabane. A common weed in hay lands eastward. A. C. Herb.: Fargo 1366.

Erigeron glabellus Nutt. *Erigeron asper* Nutt. Rough Fleabane. Rough Erigeron. A. C. Herb.: Devil's Lake 359, Leeds 360. Univ. Herb.: Grand Forks.

Erigeron bellidifolius Muhl. *Erigeron pulchellus* Michx. Robin's Plantain. Poor Robin's Plantain. Blue Spring Daisy.

Perennial by rootstocks. A. C. Herb.: Church's Ferry 361, Medora, Bathgate.

Erigeron Philadelphicus L. Philadelphia Fleabane. Common Fleabane. This weed is said to be of value in medicine as a diuretic, but is not given in the U. S. P. A. C. Herb.: Fargo 363, Valley City 364, Neche. Univ. Herb.: Grand Forks.

Antennaria plantaginifolia Richards. Plantain-leaf Everlasting. Early Everlasting. White Plantain. Mouse-ear Everlasting. Pussy-toes. , Ladies' Tobacco. Univ. Herb.: Grand Forks.

Antennaria dioica Gaertn. Mountain Everlasting. Cudweed. Cotton-weed. Cat's-ear. Moor-everlasting. A. C. Herb.: Devil's Lake 365, Fargo. Univ. Herb.: Langdon.

Gnaphalium Sprenglii Hook & Arn. Everlasting. Cudweed. Univ. Herb.: Langdon.

Silphium perfoliatum L. Cup-plant. Indian-cup. Ragged cup. A. C. Herb.: Lisbon 1176, Fargo 1178.

Iva xanthifolia Nutt. Marsh Elder. Highwater Shrub. The largest of our annual weeds. Found along roadsides and waste places generally. It is encroaching upon the grain fields where lands overflow and where the soil is moist, loose and fertile. A. C. Herb.: Minot 367, Fargo 368.

Iva axillaris Pursh. Small-flowered Marsh Elder. Found growing in alkaline soils. A. C. Herb.: Williston 369, Bottineau.

Ambrosia trifida L. Great Ragweed. King-head. Tall Ambrosia. Horseweed. Bitter-weed. Crown-seed. Wild Hemp. Richweed. Horse-cane. This is an interesting weed. As to size, it stands second only to the Marsh Elder. It produces the seeds know as "King-head" or "Crown-seed," found so commonly in the spring wheat shipped from the northwest. Because of the difficulty of removing these seeds from the grain, the grade of the wheat is reduced by purchasers. In the eastern and southern states it is looked upon as a harmless weed and good forage for horses. It is an annual, found along roadsides and river banks spreading generally into fertile grain fields. The name "King-head" is local and is due to the shape of the seeds. A. C. Herb.: Mandan 371, Tower City, Towner, Lisbon, Fargo, Williston, Edgeley, Minot.

Ambrosia trifida integrifolia T. & G. A. C. Herb.: Fargo 1240, Towner.

AMBROSIA ARTEMISIAEFOLIA L. Ragweed. Roman Wormwood. Hogweed. Bitterweed. Wild Tansy. Lesser Ragweed. Little King-head. A. C. Herb.: Fargo 373, Minot.

AMBROSIA PSILOSTACHYA DC. Western Ragweed. Perennial Ragweed. The species is similar to the last in general features, but grows from a perennial root. A. C. Herb.: Medora 375, Harlem, Leeds.

XANTHIUM CANADENSE Mill. Cocklebur. American Cocklebur. Hedgehog Burweed. Clotbur. This weed is a native of this state. As yet it has not appeared as a troublesome one in cultivated areas. It needs watching as its eastern relation, *X. strumarium*, is very troublesome when once seeded. A. C. Herb.: Medora 377, Fargo, Williston, Sims, Bismarck. Univ. Herb.: Grand Forks.

HELIOPSIS SCABRA Dunal. False Sunflower. Rough Ox-eye. A. C. Herb.: Neche 379, Fargo, Lisbon, Hillsboro, Sykeston, Devil's Lake, Valley City. Univ. Herb.: Larimore.

ECHINACEA ANGUSTIFOLIA DC. *Brauneria pallida* (Nutt.) Britt. Cone-flower. Pale Purple Cone-flower. A. C. Herb.: Valley City 380, Rolla, Hope, Bottineau, Bismarck, Towner. Univ. Herb.: Minot.

RUDBECKIA LACINIATA L. Tall Cone-flower. Green Headed Cone-flower. Found in moist thickets. Grows strongly, three to six feet high from perennial roots. It develops very large leaves, lending itself to the production of clumps of foliage upon lawns. The cultivated form is known as Golden Glow. A. C. Herb.: Neche 382, Fargo, Lake Metigoshe.

RUDBECKIA HIRTA L. Yellow Daisy. Black-eyed Susan. Golden Jerusalem. Nigger Head. This plant has always been a troublesome one in the hay fields of New England and eastern Canada. It shows but slight indications of gaining ground here. A. C. Herb.: Englevale 383, Neche, Sykeston, Rolla. Hope. Univ. Herb.: Minot.

LEPACHYS COLUMNARIS T. & G. *Ratibida columnaris* (Sims) D. Don. Coneflower. Long-headed Coneflower. A. C. Herb.: Medora 385, Harlem, Leeds, Hillsboro, Davenport, Lisbon, Valley City, Bismarck. Univ. Herb.: Minot.

LEPACHYS COLUMNARIS PULCHERRIMA T. & G. *Ratibida columnaris* (Sims) D. Don. A. C. Herb.: Sykeston 387, Bismarck, Medora. Univ. Herb.: Minot.

HELIANTHUS ANNUUS L. Common Sunflower. Annual Sunflower. The parent of cultivated sunflowers. A valuable seed producing plant. Its products afford fodder, oil and textile fiber. A. C. Herb.: Jamestown 388, Fargo, Williston, Ft. Buford. Univ. Herb.: Grand Forks.

HELIANTHUS PETIOLARIS Nutt. Prairie Sunflower. An annual similar to last species, but smaller. Found on open prairies. A. C. Herb.: Devil's Lake 390, Ft. Buford, Medora, Hope.

HELIANTHUS RIGIDUS Desf. *Helianthus scaberrimus* Ell. Stiff. Sunflower. Harsh Sunflower. A. C. Herb.: Fargo 750, Leeds, Sykeston, Bottineau, Towner. Univ. Herb.: Minot.

HELIANTHUS GIGANTEUS L. Tall Sunflower. Giant Sunflower. This is a very strong growing perennial. It makes a fine growth of foliage, if furnished plenty of moisture in a fertile soil. The roots are fleshy, rather tuberous and edible. In this region with its short growing season, any one of these rapid growing sunflowers makes a valuable addition to one's garden for ornamental effects in late summer and autumn. The perennial ones are particularly valuable. A. C. Herb.: Fargo 741, Bismarck.

HELIANTHUS MAXIMILIANA Schrad. Maximilian's Sunflower. Perennial-rooted Prairie Sunflower. Characteristic upon dry soils, growing from thickened rootstocks and fleshy roots. It has a tendency to become a weed. A. C. Herb.: Fargo 395.

HELIANTHUS STRUMOSUS L. Pale-leaved Sunflower. Wood Sunflower. Perennial from running rootstocks. Found along river banks and in wooded areas. A. C. Herb.: Leeds 396.

HELIANTHUS TUBEROSUS L. Jerusalem Artichoke. Extensively cultivated for its tuberous roots. Native in this state. A. C. Herb.: Fargo 1239.

COREOPSIS TINCTORIA Nutt. Garden Tickseed. A rather pretty flowering herb found along margins of ponds. A. C. Herb.: Medora 397.

BIDENS FRONDOSA L. Common Beggar-ticks. Stick-tight. Bur-marigold. Stick-seed. Pitchforks. A weed in low wet places, troublesome because of the awned seeds which stick to one's clothing and to the hair of domestic animals. It is especially a nuisance to sheep men. A. C. Herb.: Lisbon 398, Ft. Totten, Bismarck, Fargo, Minot, Towner. Univ. Herb.: Grand Forks.

BIDENS CERNUA L. Smaller Bur-marigold. Nodding Bur-marigold. Similar to last, but smaller plant. A. C. Herb.: Fargo 400.

HYMENOPAPPUS FILIFOLIUS Hook. Coult. Man. On dry prairies and buttes of Bad Lands. A. C. Herb.: Medora 402.

ACTINELLA ACAULIS Nutt. *Picradenia acaulis* (Nutt.) Britt. Stemless Actinella. This is one of the plants wnich admirably illustrates the effect of a dry climate and soil upon vegetation. A. C. Herb.: Buttes of Bad Lands, Medora 404.

HELENIUM AUTUMNALE L. False Sunflower. Sneeze-weed. A. C. Herb.: Walsh Co. 730, Lisbon 1109. Univ. Herb.: Grand Forks.

GAILLARDIA ARISTATA Pursh. Great-flowered Gaillardia. A. C. Herb.: Church's Ferry 405, Valley City, Devil's Lake, Bismarck, Leeds, Lisbon, Grand Rapids, Neche, Oakes, Hope, Fargo, Rolla. Univ. Herb.: Grand Forks.

ANTHEMIS COTULA DC. Chamomile. Mayweed. Dog's Chamomile. Dog's Fennel. An European plant. A roadside weed in eastern states. Not yet abunoant in this state. A. C. Herb.: Fargo 407, Neche, Sykeston.

ACHILLEA MILLEFOLIUM L. Common Yarrow. Millfoil. Sanguinary. Thousand-leaf. Woundwort. Common throughout the state. A. C. Herb.: Fargo 409, Neche, Medora, Towner, Lisbon, Minot, LaMoure, Hope. Univ. Herb.: Grand Forks.

ARTEMISIA CANADENSIS Michx. Canada Wormwood. Wild Wormwood. A. C. Herb.: Mandan 411, Towner, Sims, Bismarck.

ARTEMISIA ABROTANUM L. Southernwood. Old Man Adventive from Europe. A. C. Herb.: Jamestown 599.

ARTEMISIA LONGIFOLIA Nutt. Long-leaved Sage-brush. Sagebrush. Mugwort. Found in the Bad Lands. A. C. Herb.: Medora 417, Ft. Buford, Valley City.

ARTEMISIA LUDOVICIANA Nutt. *Artemisia gnaphalodes* Nutt. Western Mugwort. Western Wormwood. Prairie Wormwood. White Sage-brush. This plant and many others of the Artemisias are very bitter herbs. The official drug Absinthium is sometimes adulterated with the leaves and flowers of this species. The plant is very abundant over the entire western portion of the state. It is said to form a valuable element in winter forage. A. C. Herb.:

Leeds 415, Williston, Sims, Towner. Univ. Herb.: Minot.

ARTEMISIA BIENNIS Willd. Biennial Wormwood. A. C. Herb.: Glen Ullin 1133, Fargo, Jamestown.

ARTEMISIA ANNUA L. Annual Wormwood. A bad weed, very common at Fargo. A. C. Herb.: Fargo 1251.

ARTEMISIA FRIGIDA Willd. Pasture Sage-brush. White Wormwood. Wormwood Sage. Smaller White Sage-brush. Found in abundance throughout the drier prairie regions, growing from perennial roots. It is of fine foliage and much eaten by ranch cattle during winter. A. C. Herb.: Medora 413, Williston, Mandan, Valley City, Fargo. Univ. Herb.: Grand Forks.

ARTEMISIA TRIDENTATA Nutt. Common Sagebush. Sage-bush. Sage-wood. Silver-sage. Great Sage-bush. Valued as forage as in case of other Sage-brushes. A. C. Herb.: Medora 419.

ARTEMISIA CANA Pursh. Hoary Sage Brush. Univ. Herb.: Minot.

ARNICA ALPINA Olin. Coult. Man. Mountain Tobacco. Arctic Leopard's-bane. Arctic Arnica. A. C. Herb.: Ward Co. 1262. Coll., Haigh.

SENECIO PALUSTRIS Hook. Marsh Fleawort. Pale Ragwort. Marsh Groundsel. A. C. Herb.: Rolla 420, Jamestown, Wild Rice, Rutland, Englevale.

SENECIO AUREUS L. Golden Ragwort. Life-root. Squaw-wort. False Valerian. Univ. Herb.: Inkster.

SENECIO AUREUS BALSAMITAE T. & G. *Senecio Balsamitae* Muhl. Balsam Groundsel. A. C. Herb.: Valley City 423, Fargo, Rutland.

SENECIO PLATTENSIS Nutt. Britt. & Br. Fl. Prairie Ragwort. A weedy plant. A. C. Herb.: Rutland 422.

SENECIO EREMOPHILOUS Richards. Coult. Man. A. C. Herb.: Turtle Mts. 421.

SENECIO LUGENS Richards. Black-tipped Groundsel. A. C. Herb.: Valley City 1318. Coll., Perrine.

CNICUS UNDULATUS Gray. *Carduus undulatus* Nutt. Wavy-leaved Thistle. This is the most common form of thistle upon the open prairie sod. It disappears without trouble under methods of cultivation. A. C. Herb.: Devil's Lake 424, Leeds 425, Bismarck, Fargo, Page, Sykeston.

Cnicus altissimus Willd. *Carduus altissimus* L. Tall Thistle. Roadside Thistle. This thistle grows up from biennial or perennial roots, but dies out easily upon cultivated areas. A. C. Herb.: Fargo 426, Bathgate, Neche, Bismarck.

Cnicus altissimus discolor Gray. *Carduus discolor* (Muhl.) Nutt. Field Thistle. Very similar to last species. A. C. Herb.: Fargo 1360. Univ. Herb.: Bottineau.

Cnicus arvensis Hoffm. *Carduus arvensis* (L.) Robs. Canada Thistle. Creeping Thistle. Pernicious Thistle. Corn Thistle. Hard Thistle. Cursed Thistle. This weed seems to thrive well in this state. It should receive close attention to prevent further distribution. The plant is not native, but is rapidly invading from north and east. It spreads by underground jointed stems and by means of wind carried seeds, and should never be allowed to produce leaves above ground. Such prohibition placed upon it for three summers will starve the underground stems. In small clumps the most efficacious method of preventing growth is by piling quantities of straw or poorly rotted manure over the infested patches. In larger areas the work must be accomplished by means of cultivation. The growth of the thistle in the Red River Valley is very rank where it has once taken control of the soil. Entire sections northward are now abandoned to it. Herbalists, speaking of the medicinal virtues of this plant, list it as "tonic, diuretic, hepatic, anti-phlogistic and. anti-bilious". The farmer who undertakes to remove the weed from even a small area, by physical efforts, will probably agree that it has its merits in all of these lines. A. C. Herb.: Neche 428, Hillsboro, Pembina, Rolla, Park River, Devil's Lake, Hamilton, Glaston, Mayville. Univ. Herb.: Minot.

Tragopogon pratensis L. Yellow Goat's-beard. Meadow Salsify. Buck's-beard. Noon Flower. Go-to-bed-at-noon. Star-of-Jerusalem. Joseph's-flower. A. C. Herb.: Fargo 429.

Hieracium canadense Michx. Canada Hawkweed. A. C. Herb.: 430, Lisbon. Univ. Herb.: Bottineau.

Hieracium scabrum Michx. Rough Hawkweed. A woodland weed. Univ. Herb.: Grand Forks.

Crepis runcinata T. & G. Naked Stemmed Hawksbeard.

A. C. Herb.: Devil's Lake 431, Hope, Rutland, Church's Ferry. Univ. Herb.: Larimore.

PRENANTHES RACEMOSA Michx. *Nabalus racemosus* (Michx.) DC. Smooth White Lettuce. A. C. Herb.: Svea 1062, Jamestown, Valley City. Univ. Herb.: Grand Forks.

PRENANTHES ALBA L. *Nabalus albus* (L.) Hook. White Lettuce. Rattlesnake-root. White Cankerweed. Lion's-foot. A. C. Herb.: Fargo 434, Bottineau, Neche. Univ. Herb.: Grand Forks.

PRENANTHES ALTISSIMA L. *Nabalus altissimus* (L.) Hook. Tall White Lettuce. Rattlesnake-root. Lion's-foot. Univ. Herb.: Grand Forks.

LYGODESMIA JUNCEA D. Don. Rush-like Lygodesmia. Sticks. This plant has the general appearance of a member of the Pink Family. It grows throughout the lighter soiled portions of the state. Rather difficult to destroy because of its perennial root system. A. C. Herb.: Towner 435, Valley City, Jamestown, Bismarck, Leeds, Lake Metigoshe, Medora. Univ. Herb.: Devil's Lake.

TROXIMON CUSPIDATUM Pursh. *Nothocalais cuspidata* (Pursh.) Greene. False Calais. Univ. Herb.: Grand Forks.

TROXIMON GLAUCUM Nutt. *Agoseris glauca* (Pursh) Greene. Small-flowered Agoseris. False Dandelion. A. C. Herb.: Davenport 437, Leeds, Jamestown, Valley City, Fargo, Hillsboro.

TARAXACUM OFFICINALE Weber. *Taraxacum Taraxacum* (L.) Karst. Dandelion. Canker-root. Lion's-tooth. Irish Daisy. Priest's Crown. The root is collected in the fall and used as an official drug. Too abundant to be worth digging for that purpose. Its chief value seems to be the use of the leaves in early spring for "greens", for which the plant may be placed second to none. When hilled and blanched the whitened leaves are quite succulent and may be used in salads after the manner of celery. The plant is spreading very rapidly in the Red River Valley since introduction, becoming a pest in lawns. A. C. Herb.: Lisbon 439, Fargo. Univ. Herb.: Grand Forks.

LACTUCA SCARIOLA L. Prickly Lettuce. Compass Plant. This is a weed of the worst character. Recently introduced into the eastern states, it quickly over-ran the whole territory east of the Mississippi River. It makes use of the dandelion method of scattering its seeds and being from two to five high and a rank close grower, it is particularly suited to compete with the grain crops in fertile soil. At present it is being introduced sparingly in grass seed. It would be worth several millions of dollars per year to this state if it could be prevented from gaining a general footing. The appearance of the plant is like that of our common native wild lettuce, but it possesses yellow flowers and the leaves and stems bear long needl pointed prickles. A. C. Herb.: Fargo 760, Casselton.

Lactuca pulchella DC. Native Wild Lettuce. Large-flowered Blue Lettuce. A comparatively harmless plant. A. C. Herb.: Medora, Flats in Bad Lands 441, Lisbon, Davenport, Argusville, Page, Hillsboro, Towner, Devil's Lake, Bottineau, Dunseith.

Lactuca leucophaea Gray. *Lactuca spicata* (Lam.) Hitchc. Tall Blue Lettuce. A. C. Herb.: Fargo 1241, Ransom Co.

Sonchus asper Vill. *Sonchus asper* (L.) All. Spiny or Sharp-fringed Sow-thistle. A weed found in waste places and around dwellings. Naturalized from Europe. A. C. Herb.: Hillsboro 445, Fargo 1221.

Sonchus oleraceus L. Annual Sow-Thistle. Milk-Thistle. Hare's Lettuce. A bad weed which is taking possession of the land in some portions of the northern part of the state. A. C. Herb.: Pembina 1252.

LOBELIACEAE. LOBELIA FAMILY.

Lobelia syphilitica L. Great Lobelia. A. C. Herb.: Englevale 447.

Lobelia leptostachys A. DC. Spiked Lobelia. Univ. Herb.: Grand Forks.

Lobelia spicata Lam. Pale Spiked Lobelia. A. C. Herb.: Harlem 448, Hope, Bathgate, Fuller's Lake. Univ. Herb.: Pleasant Lake.

Lobelia Kalmii L. Kalm's Lobelia. Brook Lobelia. A. C. Herb.: Lake Metigoshe 450, Towner. Univ. Herb.: Bottineau.

CAMPANULACEAE. CAMPANULA FAMILY. BELLFLOWER FAMILY.

Campanula rotundifolia L. Harebell. Blue Bells of Scotland. Round-leaved Bellflower. Ladies' Thimbles. This delicate little flower is found throughout the state. As it is a perennial it ought to do well as a bed plant if properly sheltered. A. C. Herb.: Jamestown 452, Valley City, Hope, Church's Ferry, Fargo, Towner, Page, Rutland. Univ. Herb.: Grand Forks.

ERICACEAE. HEATH FAMILY.

Pyrola elliptica Nutt. Shin-leaf. A. C. Herb.: Neche 1370.

PRIMULACEAE. PRIMROSE FAMILY.

Dodecatheon Meadia L. Shooting Star. American Cowslip. Pride-of-Ohio. A. C. Herb.: Rolla 455.

Androsace occidentalis Pursh. Androsace. A. C. Herb.: Bismarck 456, Svea, Valley City. Univ. Herb.: Dickinson.

Androsace septentrionalis L. Coult. Man. Found on the dry prairies. A. C. Herb.: Leeds 457.

Steironema ciliatum Raf. Fringed Loosestrife. Found in moist shaded places. A. C. Herb.: Neche 458, Fargo, Wild Rice, Medora, LaMoure, Jamestown, Ft. Buford, Bathgate, Lake Metigoshe. Univ. Herb.: Grand Forks.

Steironema lanceolatum Gray. Lance-leaved Loosestrife. Found everywhere in moist shaded areas. A. C. Herb.: Page 460, Hope, Jamestown, Harlem. Univ. Herb.: Mayville.

Glaux maritima L. Sea Milkwort. Black Saltwort. Found in alkaline depressions. A. C. Herb.: Lidgerwood 462, Devil's Lake, Ransom Co.

Centunculus minimus L. Chaffweed. False Pimpernel. A. C. Herb.: Svea 1125. Coll., Fieldstad.

OLEACEAE. OLIVE FAMILY.

Fraxinus Americana L. White Ash. Under cultivation in various points in state. A. C. Arboretum. This is a valuable timber and shade tree, but it is not known to be a native of the state. This would rather indicate that it cannot withstand the climatic conditions; for its mode of seed distribution is good. It has not proven hardy under cultivation at this point.

Fraxinus pubescens Lam. *Fraxinus Pennsylvanica* Marsh. Red Ash. Not common. Along streams and lake margins. A timber tree. A. C. Herb.: Devil's Lake 463, Rutland.

Fraxinus viridis Michx. *Fraxinus lanceolata* Borck. Green Ash. A hard, strong timber tree. This tree should be used for cultivation purposes in this state instead of the White Ash. Its character is such as to indicate that it would be hardy and make a good growth. Found everywhere along lake margins and streams. A. C. Herb.: Fargo 464. Custer Trail Ranch near Medora in Bad Lands. Univ. Herb.: Grand Forks.

APOCYNACEAE. DOGBANE FAMILY.

Apocynum androsaemifolium L. Spreading Dogbane. Honey-bloom. Grows in thickets throughout the state. The root was at one time an official drug for same purpose as next. A. C. Herb.: Lake Metigoshe 466, Bathgate, Valley City, Neche.

Apocynum cannabinum L. Indian Hemp. Amy-root. Bowman's Root. Indian Physic. The root is used as an official drug. See U. S. P. In rich soils along river banks in thickets. A. C. Herb.: Valley City 468, Harlem, Tower City, Power, Devil's Lake, Fargo. Univ. Herb.: Grand Forks.

ASCLEPIADACEAE. MILKWEED FAMILY.

Asclepias purpurascens L. Purple Milkweed. Thickets and dry banks. A. C. Herb.: Fargo 470.

Asclepias incarnata L. Swamp Milkweed. A. C. Herb.: Devil's Lake 471, Tower City, Fuller's Lake, Power. Univ. Herb.: Grand Forks.

Asclepias speciosa Torr. Showy Milkweed. This plant as well as others of the family is recommended by gardeners as ornamental. It is round in moist damp areas, along streams. A. C. Herb.: Tower City 473, Devil's Lake, Fuller's Lake. Univ. Herb.: Grand Forks.

Asclepias Cornuti Decaisne. *Asclepias Syriaca* L. Common Milkweed. Silkweed. Found in fields, along roadsides and waste places. A. C. Herb.: Devil' Lake 475, Lisbon, Bismarck, Fargo, Valley City.

ASCLEPIAS OVALIFOLIA Decaisne. Oval-leaved Milkwort. Found upon open prairies and in open woodlands. A. C. Herb.: Fargo 477, Bismarck, Sykeston, Hillsboro, Verona, Valley City. Univ. Herb.: Grand Forks.

ASCLEPIAS VERTICILLATA L. Whorled Milkweed. Found upon the open prairie, in dry sandy areas. A. C. Herb.: Hope 478, Page, Davenport, Bismarck. Univ. Herb.: Grand Forks.

ACERATES VIRIDFLORA LINEARIS Gray. Green Milkweed. A. C. Herb.: Power 479, Milnor 1187.

GENTIANACEAE. GENTIAN FAMILY.

GENTIANA SERRATA Gunner. *Gentiana detonsa* Rottb. Smaller Fringed Gentian. Found in moist soils. A. C. Herb.: Towner 481, Jamestown.

GENTIANA AMARELLA L. *Gentiana acuta* Michx. Northern Gentian. Grows in bogs and wet places. A. C. Herb.: Lake Metigoshe 483, Devil's Lake, Valley City.

GENTIANA PUBERULA Michx. Downy Gentian. Found on open dry prairies. This beautiful little plant might be used to advantage for ornamental purposes. Other members are no less beautiful, but perhaps not quite so hardy. A. C. Herb.: Fargo 485, Devil's Lake. Univ. Herb.: Grand Forks.

GENTIANA SAPONARIA L. Soapwort Gentian. A. C. Herb.: Neche 487.

GENTIANA ANDREWSII Griseb. Closed Gentian. Blind Gentian. Found in wet areas. A. C. Herb.: Devil's Lake 488, Grand Forks.

POLEMONIACEAE. PHLOX FAMILY.

PHLOX PILOSA L. Hairy Phlox. A handsome prairie plant. A .C. Herb.: Fargo 1352.

PHLOX CANESCENS T. & G. Coult. Man. Canescent Phlox. A. C. Herb.: Medora 785, Williston.

GILIA LINEARIS Gray. *Collomia linearis* Nutt. Narrow-leaved Gilia. A. C. Herb.: Fargo 489, Neche, Jamestown, Medora.

HYDROPHYLLACEAE. WATERLEAF FAMILY.

Hydrophyllum Virginicum L. Virginia Water-leaf. Everywhere in rich woodland soils. This early spring plant grows perennial from the roots, giving a wealth of foliage and light blue flowers. It furnshes a fine growth under cultivation in protected places. A. C. Herb.: Wahpeton 491, Fargo. Univ. Herb.: Grand Forks.

Ellisia Nyctelea L. *Macrocalyx Nyctelea* (L.) Kuntze. This native plant grows normally in low wet spots, but since cultivation of the land it has found the wheat areas of the Red River Valley about right for it. It is a great seed producer. The seeds are large, germinate early in spring and make a strong first growth. The weed thus does much damage by smothering cereals in early spring. It is difficult to recommend any way of combating the weed except by means of a cultivated crop or summer fallow. A. C. Herb.: Fargo 493, Wahpeton. Univ. Herb.: Grand Forks.

Phacelia circinata Jacq. f. Coult. Man. *Phacelia leucophylla* Torr. A. C. Herb.: Medora 495.

BORRAGINACEAE. BORAGE FAMILY.

Heliotropium Curassavicum L. Seaside Heliotrope. Found in alkaline areas. A. C. Herb.: Ft. Totten 496, Jamestown.

Cynoglossum Virginicum L. Wild Comfrey. Found in open woods. A bur producer, detrimental to sheep husbandry. A. C. Herb.: Fargo 497.

Echinospermum Virginicum Lehm. *Lappula Virginiana* (L.) Greene. Beggar Lice. Virginia Stick-seed. Beggar's Ticks. A bur producing weed, growing in woodland and thickets, bad for wool producing animals. Univ. Herb.: Grand Forks.

Echinospermum deflexum Americanum Gray. *Lappula Americana* (Gray) Rydb. A. C. Herb.: Rolla 498, Fargo, Valley City.

Echinospermum Lappula Lehm. *Lappula Lappula* (L.) Karst. Bur-seed. European Stick-seed. An introduced weed which grows in waste places. A. C. Herb.: Harlem 501, Fargo, Neche, Larimore.

Echinospermum Redowskii occidentale Watson. *Lappula Texana* (Scheele) Britt. Hairy Stick-seed. Found upon open prairies in dry places. A. C. Herb.: Lisbon 503, Fargo, Sykeston.

Krynitzkia virgata Gray. Coult. Man. Bad Lands. A. C. Herb.: Medora 505.

Krynitzkia glomerata Gray. *Oreocarya glomerata* (Pursh) Greene. A. C. Herb.: Bad Lands, Medora 506.

Lithospermum hirtum Lehm. *Lithospermum Gmelini* (Michx.) Hitchc. Hairy Puccoon. A. C. Herb.: Lidgerwood 511. Univ. Herb.: Grand Forks.

Lithospermum canescens Lehm. Puccoon of the Indians. Hoary Puccoon. Found everywhere on open prairies. A. C. Herb.: Hope 510, Fargo, Page. Univ. Herb.: Grand Forks.

Lithospermum angustifolium Michx. Narrow-leaved Puccoon. A. C. Herb.: Valley City 1111. Coll., Fieldstad. Jamestown. Coll., Schmidt.

Onosmodium Carolinianum molle Gray. *Onosmodium molle* Michx. False Gromwell. A. C. Herb.: Valley City 507, Medora, Fargo, Jamestown.

CONVOLVULACEAE. MORNING-GLORY FAMILY.

Convolvulus sepium L. Hedge Bindweed. Rutland Beauty. Bellbind. Hedge Lily. Grows in thickets and woodlands. A. C. Herb.: Minot 512, Fargo, Neche, Bathgate, Tower City, Bismarck. Univ. Herb.: Grand Forks.

Convolvulus sepium repens Gray. *Convolvulus repens* L. Trailing Bindweed. A. C. Herb.: Ward Co. 1264, Tower 1332.

Cuscuta Gronovii Willd. Gronovius' Dodder. Love-vine. Dodder. Found growing upon shrubbery, hazel brush, etc. A. C. Herb.: Ft. Totten 514, Turtle Mts., Bismarck, Fargo. Univ. Herb.: Grand Forks.

SOLANACEAE. NIGHTSHADE FAMILY. POTATO FAMILY.

Solanum triflorum Nutt. Three-flowered Nightshade. Cut-leaved Nightshade. Waste places. A. C. Herb.: Fargo 516, Sykeston, Leeds, Devil's Lake, Page.

Solanum nigrum L. Common Nightshade. Black Nightshade. Garden Nightshade. Morel. Duscle. Hound's Berry. Deadly Nightshade. A poisonous plant. Children are apt to be poisoned by eating the rather fine looking berries. A. C. Herb.: Fargo 518.

Solanum rostratum Dunal. Prickly Tomato. Buffalo Bur. Prickly Nightshade. This weed as yet is not very common but shows some capabilities of becoming a weed here as elsewhere. It also harbors or furnishes food for the Colorado potato beetle. A. C. Herb.: Medora 520, Ft. Buford, Necne, Fargo, New England City. Univ. Herb.: Grand Forks.

Physalis Virginiana Mill. Virginia Ground Cherry. A. C. Herb.: Lisbon 1145.

Physalis lanceolata Michx. Prairie Ground-cherry. Found on open dry prairies. A. C. Herb.: Hope 522, Devil s Lake, Fargo, Valley City, Bismarck. Univ. Herb.: Larimore.

SCROPHULARIACEAE. FIGWORT FAMILY.

Verbascum Thapsus L. Common Mullen. Great Mullen. Velvet Dock. Peter's-staff. Ice-leaf. Woolly Müllen. Introduced at a few points in the Valley. It might become a bad weed in our fertile river lands. To kill, cut below the crown. A. C. Herb.: Fargo 524, also seen at Mayville.

Linaria vulgaris Mill. *Linaria Linaria* (L.) Karst. Ramsted. Butter-and-Eggs. Toad Flax. Flax-weed. Eggs-and-Bacon. Introduced as an ornamental plant, for which purpose it is not sufficiently valuable to make up for its weedy habits. It spreads by seeds and when once in the soil holds tenaciously and spreads by means of creeping and broken rootstocks. A. C. Herb.: Fargo 525, Montpelier 1230.

Scrophularia nodosa Marylandica, Gray. *Scrophularia Marylandica* L. Figroot. Heal-all. Pilewort. A. C. Herb.: Medora 526, Davenport.

Pentstemon pubescens Soland. *Pentstemon hirsutus* (L.) Willd. Hairy Beard-tongue. A. C. Herb.: Lisbon 532. Univ. Herb.: Grand Forks.

Pentstemon caeruleus Nutt. Coult. Man. *Pentstemon angustifolia* Pursh. Blue Beard-tongue. A. C. Herb.: Medora 529, Valley City, New England City.

PENTSTEMON GRACILIS Nutt. Slender Beard-tongue. Found in moist prairies. This and other members of the genus, it seems, might be cultivated to pood purpose as a garden flower. A. C. Herb.: Fargo 534, Bismarck, Valley City, Page, Minot, Jamestown, Sykeston, Church's Ferry. Univ. Herb.: Grand Forks.

PENTSTEMON ALBIDUS Nutt. White-flowered Beard-tongue. A. C. Herb.: Jamestown 1076. Coll., Schmidt. Valley City. Coll., Perrine. Univ. Herb.: Grand Forks.

PENTSTEMON GRANDIFLORUS Nutt. Large-flowered Beard-tongue. A. C. Herb.: Mandan 528.

MIMULUS RINGENS L. Square-stemmed Monkey-flower. Found in swampy places. A. C. Herb.: Lisbon 535.

MIMULUS LUTEUS L. Yellow Monkey-flower. Cultivated as an ornamental house plant. Univ. Herb.: Grand Forks.

HERPESTIS ROTUNDIFOLIA Pursh. *Monniera rotundifolia* Michx. Round-leaved Hedge-Hyssop. A. C. Herb.: Fargo 1250.

GRATIOLA VIRGINIANA L. Clammy Hedge-Hyssop. A. C. Herb.: Ft. Totten 528, Fargo, Devil's Lake, Casselton. Univ. Herb.: Grand Forks.

VERONICA ANAGALLIS L. *Veronica Anagallis-aquatica* L. Water Speedwell. Water Pimpernel. Found in swamps and ditches. A. C. Herb.: Lisbon 1110. Coll., Fieldstad.

VERONICA PEREGRINA L. Neckweed. Purslane Speedwell. A. C. Herb.: Fargo 538. Univ. Herb.: Bottineau.

GERARDIA ASPERA Dougl. Rough Purple Gerardia. A. C. Herb.: Sykeston 1139, Towner.

GERARDIA PURPUREA L. Purple Gerardia. Univ. Herb.: Grand Forks.

GERARDIA TENUIFOLIA Vahl. Slender Gerardia. A. C. Herb.: Fargo 540, Sykeston, Forman.

CASTILLEIA SESSILIFLORA Pursh. Downy Painted-cup. Prairie Painted-cup. A. C. Herb.: Valley City 1116, Rutland. Univ. Herb.: Devil's Lake.

ORTHOCARPUS LUTEUS Nutt. Yellow Orthocarpus. Found upon dry areas throughout the state. A. C. Herb.: Medora 541, Lake Metigoshe, Jamestown. Univ. Herb.: Church's Ferry.

Pedicularis lanceolata Michx. Swamp Lousewort. A. C. Herb.: Towner 544, Englevale, Page. Univ. Herb.: Grand Forks.

OROBANCHACEAE. BROOM-RAPE FAMILY.

Aphyllon fasciculatum Gray. *Thalesia fasciculata* (Nutt.) Britt. Naked Broom-rape. Pale Broom-rape. Clustered or Yellow Cancer-root. A. C. Herb.: Valley City 546, Jamestown.

Aphyllon Ludovicianum Gray. *Orobanche Ludoviciana* Nutt. Western Broom-rape. A. C. Herb.: Medora 549. Univ. Herb.: Grand Forks.

LENTIBULARIACEAE. BLADDERWORT FAMILY.

Utricularia vulgaris L. Greater Bladderwort. Hooded Water-milfoil. Pop-weed. An aquatic or floating plant in rivers, ponds and lakes. An interesting plant for school aquaria. A. C. Herb.: Fargo 550. Univ. Herb.: Grand Forks.

VERBENACEAE. VERVAIN FAMILY.

Verbena urticaefolia L. White Vervain. Nettle-leaved Vervain. A. C. Herb.: Bathgate 551, Lisbon. Univ. Herb.: Minot.

Verbena hastata L. Blue Vervain. Wild Hyssop. A. C. Herb.: Fargo 552, Lake Metigoshe, Sykeston, Jamestown, Bismarck, Wild Rice. Univ. Herb.: Grand Forks.

Verbena stricta Vent. Hoary Vervain. Mullen Vervain. A. C. Herb.: Lisbon 1114. Coll., Fieldstad.

Verbena bracteosa Michx. Large-bracted Vervain. A. C. Herb.: Medora 554, Leeds, Englevale.

Phryma Leptostachya L. Lopseed. A. C. Herb.: Neche 556, Wild Rice, Fargo. Univ. Herb.: Grand Forks.

LABIATAE. MINT FAMILY.

Teucrium occidentale Gray. Hairy Germander. A. C. Herb.: Harlem 558.

Mentha Canadensis L. Wild Mint. American Wild Mint. May be used as a cultivated mint for table use. Also used in the manufacture of the drug known as Menthol. A. C. Herb.: Englevale 559, Rolla, Bismarck, Jamestown, Leeds, Lake Metigoshe, Fargo, Lisbon, Neche, Hope. Univ. Herb.: Rugby Junction.

LYCOPUS LUCIDUS AMERICANUS Gray. *Lycopus lucidus* Turcz. Western Water Hoarhound. A. C. Herb.: Englevale 561, Leeds. Univ. Herb.: Grand Forks.

LYCOPUS SINUATUS Ell. *Lycopus Americanus* Muhl. Cut-leaved Water Hoarhound. A. C. Herb.: Ft. Totten 563, Neche, Bismarck, Wild Rice, Fargo.

HEDEOMA HISPIDA Pursh. Rough Pennyroyal. A. C. Herb.: Ft. Buford 565, Sykeston, Medora.

MONARDA FISTULOSA L. Wild Bergamot. Horse Mint. Balm Plant. May be made of use in clumps of lawn herbs. A. C. Herb.: Neche 567, Medora, Minot, Ft. Buford, Bismarck, Fargo. Univ. Herb.: Minnewaukon.

LOPHANTHUS ANISATUS Benth. *Agastache anethiodora* (Nutt.) Britt. Fragrant Giant-Hyssop. A. C. Herb.: Fargo 569. Lisbon, Lake Metigoshe. Univ. Herb.: Ft. Totten.

NEPETA CATARIA L. Catmint. Catnip. A. C. Herb.: Fargo 571.

DRACOCEPHALUM PARVIFLORUM Nutt. American Dragon-head. Fargo 572, Devil's Lake. Univ. Herb.: Inkster.

SCUTELLARIA LATERIFLORA L. Mad-dog Skullcap. Madweed. Hoodwort. An official drug. See U. S. P. A. C. Herb.: Valley City 1131. Coll., Westergaard.

SCUTELLARIA PARVULA Michx. Small Skullcap. A. C. Herb.: Lisbon 1315. Coll., Fieldstad.

SCUTELLARIA GALERICULATA L. Hooded Willow-herb. Marsh Skullcap. A. C. Herb.: Turtle Mts. 574, Ft. Totten.

PHYSOSTEGIA PARVIFLORA Nutt. Purple or Western Lion's Heart. A. C. Herb.: Minot 576, Fargo.

PHYSOSTEGIA VIRGINIANA Benth. Lion's Heart. Obedient Plant. Univ. Herb.: Grand Forks.

LEONORUS CARDIACA L. Common Motherwort. An introduced weed. Univ. Herb.: Minot.

STACHYS PALUSTRIS L. Hedge Nettle. Marsh Woundwort. A. C. Herb.: Ft. Buford 571, Lisbon, Davenport, Hope, Sykeston, Leeds, Harlem, Fargo, Lake Metigoshe, Rolla, Neche, Towner. Univ. Herb.: Grand Forks.

STACHYS ASPERA Michx. Rough Hedge Nettle. A. C. Herb.: Fargo 1161. Univ. Herb.: Grand Forks.

PLANTAGINACEAE. PLANTAIN FAMILY.

PLANTAGO MAJOR L. Common Plantain. Greater Plantain. Dooryard Plantain. This weed is now being introduced in grass seed. It is always a troublesome weed in lawns. To kill, it must be cut below the leaf crown. A. C. Herb.: Valley City 580, Jamestown, LaMoure, Tower City, Fargo. Univ. Herb.: Grand Forks.

PLANTAGO RUGELII Dec. Rugel's Plantain. White Man's Foot. A. C. Herb.: Lisbon 582.

PLANTAGO ERIOPODA Torr. Saline Plantain. A. C. Herb.: Rolla 583, Tower City, Oakes. Univ. Herb.: Grand Forks.

PLANTAGO PATAGONICA GNAPHALIOIDES Gray. *Plantago Purshii* R. & S. Woolly Plantain. A. C. Herb.: Ft. Buford 583, Medora.

PLANTAGO PATAGONICA NUDA Gray. A. C. Herb.: Medora 587, Dickinson, Bismarck.

NYCTAGINACEAE. FOUR-O'CLOCK FAMILY.

OXYBAPHUS NYCTAGINEUS Sweet. *Allionia nyctaginea* Michx. Heart-leaved Umbrella-wort. A. C. Herb.: Valley City 588, Devil's Lake, Hillsboro, Medora, Lisbon. Univ. Herb.: Minot.

OXYBAPHUS HIRSUTUS Sweet. *Allionia hirsuta* Pursh. A. C. Herb.: Page 590, Medora, Bismarck, Lidgerwood, Lake Metigoshe, Minot.

OXYBAPHUS ANGUSTIFOLIUS Sweet. *Allionia linearis* Pursh. Narrow-leaved Umbrella-wort. Not common. A. C. Herb.: Medora 591.

OXYBAPHUS sp. Dstinct from other species, in that it has petioled, linear-oblong, glabrous leaves; and peduncles solitary in the axils. Collected in Bad Lands. A. C. Herb.: 1311. There is also another form similar to the foregoing, distinguished by the stem being densely hirsute, the hairs being flat and many celled. A. C. Herb.: 1312.

Abronia micrantha Torr. Coult. Man. Pink Abronia. A. C. Herb.: Medora 592.

ILLECEBRACEAE. KNOTWORT FAMILY.

Paronychia sessiliflora Nut. Low Whitlow-wort. A. C. Herb.: Medora 1041.

AMARANTACEAE. AMARANTH FAMILY.

Amaranthus hypochondriacus L. *Amaranthus hybridus* L. Slender Pigweed. A. C. Herb.: Argusville 1306.

Amaranthus retroflexus L. Pigweed. Rough Pigweed. Red Root. A troublesome weed in cultivated fields, especially in gardens and potato grounds. It is much liked as forage by pigs. A. C. Herb.: Minot 593, Fargo, Bismarck. Univ. Herb.: Grand Forks.

Amaranthus chlorostachys Willd. *Amaranthus hybridus* L. Slender Pigweed. A. C. Herb.: Lisbon 1097. Coll., Fieldstad.

Amaranthus albus L. *Amaranthus graecizans* L. Tumble-weed. White Tumble-weed. A. C. Herb.: Leeds 595, Harlem. Univ. Herb.: Grand Forks, Minot.

Amaranthus blitoides Wats. Prostrate Amaranth. A. C. Herb.: Fargo 597, Minot.

CHENOPODIACEAE. GOOSEFOOT FAMILY.

Cycloloma platyphyllum Moq. *Cycloloma atriplicifolium* (Spreng.) Coult. Winged Pigweed. A. C. Herb.: Milnor 1101, Crystal Springs 1242.

Monolepis chenopodioides Moq. Coult. Man. *Monolepis Nuttalliana* (R. & S.) Greene. Monolepis. A. C. Herb.: Valley City 1153. Coll., Perrine.

Chenopodium leptophyllum Nutt. Narrow-leaved Goosefoot. A. C. Herb.: New Yorktown, Kidder Co. 1319. Coll., Perrine.

Chenopodium album L. Lamb's Quarters. Pigweed. White Goosefoot. This tall rank growing weed is capable of doing considerable damage in grain fields, but is especially troublesome in fertile gardens. Like the amaranths it produces an abundance of small black seeds, which continue to fall to the ground throughout the year. Its only merit seems to be that its first succulent growth makes a valuable spring dish when served as "greens". A. C. Herb.: Minot 600, Devil's Lake, Williston, Sims, Fargo. Univ. Herb.: Devil's Lake.

CHENOPODIUM ALBUM VIRIDE Moq. Green Pigweed. A. C. Herb.: Devil's Lake 1367.

CHENOPODIUM MURALE L. Nettle-leaved Goosefoot. Sowbane. An immature specimen somewhat doubtfully referred to this species. A. C. Herb.: Ft. Ransom 1317. Coll., Perrine.

CHENOPODIUM HYBRIDUM L. Maple-leaved Goosefoot. This is rather a rank weed in fertile soils along river courses, in waste places, potato patches, etc. A. C. Herb.: Lake Metigoshe 602, Minot, Fargo.

CHENOPODIUM GLAUCUM L. Oak-leaved Goosefoot. Probably not common. A. C. Herb.: Ward Co. 1301, Coll., Haigh. Ft. Ransom 1349. Coll., Perrine.

ATRIPLEX PATULA L. Spreading Orache. A. C. Herb.: Glen Ullin 1130. Coll., Westergaard.

ATRIPLEX PATULA HASTATA Gray. *Atriplex hastata* L. Halberd-leaved Orache. A. C. Herb.: Devil's Lake 1304.

ATRIPLEX ENDOLEPIS Wats. Coult. Man. A. C. Herb.: Bad Lands at Sully's Springs 1046, Glen Ullin, Valley City.

ATRIPLEX ARGENTEUM Nutt. Silvery Orache. Silvery Atriplex. A. C. Herb.: Medora 604, Turtle Mts., Valley City. Univ. Herb.: Minot.

ATRIPLEX NUTTALLII Wats. Coult. Man. Saltbush. Nuttall's Saltbush. Perennial. One of the winter forage shrubs of the western ranges. Much valued by ranchmen. Seeds should be collected and seeded upon bare alkaline areas previous to the spring rains. A. C. Herb.: Sims 1160.

ATRIPLEX CONFERTIFOLIA Wats. Coult. Man. Spring Saltbush. Same character in general forage value as last. All of the perennial saltbushes show a high nitrogen content, and seem to be of nutritive value. A. C. Herb.: Medora 606.

ATRIPLEX CANESCENS James. Coult. Man. Canescent or Fuzzy Saltbush. Shad Scale. The greatest seed and forage producer of the Atriplex type of saltbush. A. C. Herb.: Medora 607, Ft. Buford, Glen Ullin, White Earth.

EUROTIA LANATA Moq. Coult. Man. Winter Fat. White Sage. Saltbush. This is one of the largest of the so-called saltbushes, and is found in abundance throughout the Bad Lands. All kinds of stock relish the seeds and leaves. Stockmen highly prize the plant for its value during the winter season. They may find it worthy of cultivation. It is said to act as a sort of tonic, and may thus have other merits in keeping up the health of the cattle. The seeds of this and of other native saltbushes may be sowed upon alkaline areas in the spring. These plants are great drouth resisters. A. C. Herb.: Medora 608, Ft. Buford.

AXYRIS AMARANTHOIDES L. This is an introduced plant, a native of northern Asia. So far as we know it has only been recorded for one other point in North America. It was first noticed by Fletcher ten miles east of Winnipeg, 1886. The nature of the weed indicates that it will be a dense occupant of the soil and a great seed producer. A. C. Herb.: Dump yard at Pembina 1162. Collected, October, 1899.

CORISPERMUM HYSSOPIFOLIUM L. Bugseed. A. C. Herb.: Mandan 610.

SALICORNIA HERBACEA L. Slender Glasswort. Marsh Samphire. A. C. Herb.: Lidgerwood 1163. Univ. Herb.: Minot.

SUAEDA DEPRESSA Wats. *Dondia depressa* (Pursh) Britt. Western Blite. A. C. Herb.: Sykeston 611, Bottineau, Devil's Lake. Univ. Herb.: Larimore.

SUAEDA DEPRESSA ERECTA Wats. Coult. Man. A. C. Herb.: Horsehead Lake, Kidder Co. 1353. Coll., Perrine.

SALSOLA TRAGUS L. Saltwort. Russian Thistle. Russian Cactus. This sharp or spiny-leaved annual plant is neither a thistle nor a cactus, but under dry rather sterile conditions it develops into a troublesome weed. If there is sufficient soil moisture to develop a cereal crop, it need not give any trouble. In regions where it has occupied the land, farmers must modify methods so as to give the regular crop the start. A. C. Herb.: Lisbon 613, Fargo, Lidgerwood, Jamestown, Milnor, Bismarck, Mayville, Napoleon.

POLYGONACEAE. BUCKWHEAT FAMILY.

ERIOGONUM FLAVUM Nutt. Yellow Eriogonum. A. C. Herb.: Medora 614, Rolla.

ERIOGONUM PAUCIFLORUM Pursh. Coult. Man. Few-flowered Eriogonum. A. C. Herb.: Medora 1047.

ERIOGONUM MULTICEPS Nees. Coult. Man. Branched Eriogonum. A. C. Herb.: Third Creek, Bad Lands 1181. Coll., Perrine.

RUMEX VENOSUS Pursh. Veined Dock. A. C. Herb.: Medora 616, Cannon Ball 1270.

RUMEX BRITTANNICA L. Great Water-Dock. A. C. Herb.: Bathgate 620.

RUMEX SALICIFOLIUS Weinm. White Dock. Willow-leaved Dock. This dock tends to become a weed in wet pastures and meadows. It should be dug up by the roots and prevented from seeding. A. C. Herb.: Neche 618, Page, Bismarck, Lisbon, Jamestown, Hope, Fargo. Univ. Herb.: Grand Forks.

RUMEX VERTICILLATUS L. Swamp Dock. A. C. Herb.: Lisbon 1167. Coll., Fieldstad.

RUMEX CRISPUS L. Curled Dock. Narrow Dock. Sour Dock. The leaves of this plant are valued by many as a sourse of "greens". The roots furnish an official drug. See U. S. P. A troublesome weed in wet fertile soils and low meadows. A. C. Herb.: Fargo 622, Jamestown.

RUMEX OCCIDENTALIS Wats. Coult. Man. Western Dock. A. C. Herb.: 617.

RUMEX MARITIMUS L. *Rumex persicarioides* L. Golden Dock. A. C. Herb.: Leeds 624, Neche, Lisbon, Hope, Jamestown, Fargo.

RUMEX ACETOSELLA L. Field Sorrel. Sheep Sorrel. Horse Sorrel. Arrow-head Sorrel. This weed does much damage upon light sandy soils in eastern states. It is not liable to do much damage in our alkaline areas. A. C. Herb.: Fargo 626.

POLYGONUM AVICULARE L. Knotgrass. Knotweed. Doorweed. Chicken Grass. Goose Grass. A weed about farm buildings and trodden grounds. A. C. Herb.: Fargo 627. Univ. Herb.: Rugby Junction.

POLYGONUM ERECTUM L. Erect Knotweed. Similar to last named species, but erect. Rather weedy in tendency. A. C. Herb.: Sykeston 628, Jamestown, Mandan, Medora, Towner.

POLYGONUM RAMOSISSIMUM Michx. Bushy Knot-weed. A.

C. Herb.: Towner 630, Harlem, Fargo, Davenport, Sykeston, Bismarck. Univ. Herb.: Minot.

POLYGONUM LAPATHIFOLIUM L. Dock-leaved Persicaria. A. C. Herb.: Towner 632, Leeds, Argusville, Hope, Valley City.

POLYGONUM LAPATHIFOLIUM INCANUM Koch. A. C. Herb.: Page 634, Fargo, Lake Metigoshe.

POLYGONUM LAPATHIFOLIUM NODOSUM (Pers.) Small. Britt. & Br. Fl. A. C. Herb.: Page 634.

POLYGONUM AMPHIBIUM L. Water Persicaria. A. C. Herb.: Lake Metigoshe 636. Univ. Herb.: Bottineau.

POLYGONUM MUHLENBERGII Wats. *Polygonum emersum* (Michx.) Britt. Swamp Persicaria. A. C. Herb.: Williston 638, Jamestown, Fargo, Edgeley.

POLYGONUM SAGITTATUM L. Arrow-leaved Tear-thumb. A. C. Herb.: Bottineau 1305.

POLYGONUM CONVOLVULUS L. Black Bind Weed. Wild Buckwheat. This plant is one of the most detrimental weeds in the grain fields of the state. Its chief damage is done upon the wheat crop, where it reduces the yield by tangling, choking and abundant leaf production. The seeds in the product cut down the market grade. After cultivating it out of the soil much care should be exercised in the cleaning of seed grain. A. C. Herb.: Davenport 640, Leeds, Sykeston, LaMoure and throughout the state.

POLYGONUM DUMETORUM SCANDENS Gray. *Polygonum scandens* L. Climbing False Buckwheat. In woodland. A. C. Herb.: Turtle Mts. 1164, Jamestown.

ELAEAGNACEAE. OLEASTER FAMILY.

ELAEAGNUS ARGENTEA Pursh. Silver-berry. Everywhere common west of the James River Valley. It is one of the most ornamental of shrubs. Particularly adapted to dry soils and dry atmosphere. Dakotans should improve this and its ally, the Bullberry. A. C. Herb.: Valley City 642, Devil's Lake, White Earth. Univ. Herb.: Grand Forks.

SHEPHERDIA CANADENSIS Nutt. *Lepargyraea Canadensis* (L.) Greene. Canada Buffalo-berry. Useful as an ornamental plant, much smaller than the Silver-berry. A. C. Herb.: Turtle Mts. 643, Milton 1182.

Shepherdia argentea Nutt. *Lepargyraea argentea* (Nutt.) Greene. Buffalo-berry. Bull-berry. This shrubby tree is a native fruit producer worthy of the careful work of the horticulturist. It bears fruit in great abundance, currant-like in form, in large clusters. For the purpose of jelly making, the berry has few if any equals. As a shrub for ornamental clumps and hedges we place the plant second to none. It is hardy in all regions of the state and is found in extended thickets west of the Missouri. A. C. Herb.: Medora 644, Fargo, cultivated, Mandan, Bismarck.

SANTALACEAE. SANDALWOOD FAMILY.

Comandra umbellata Nutt. Bastard Toad-flax. A. C. Herb:. Bathgate 646, Rutland, Bismarck. Univ. Herb.: Grand Forks.

Comandra pallida A. DC. Pale Comandra. A. C. Herb.: Medora 648.

EUPHORBIACEAE. SPURGE FAMILY.

Euphorbia Geyeri Engelm. Geyer's Spurge. Univ. Herb.: Grand Forks.

Euphorbia petaloidea Engelm. White-flowered Spurge. A. C. Herb.: Medora 649.

Euphorbia serpens H B K. Round-leaved Spreading Spurge. A. C. Herb.: Glen Ullin 1129. Coll., Westergaard.

Euphorbia serpyllifolia Pers. Thyme-leaved Spurge. A. C. Herb.: Davenport 650.

Euphorbia glyptosperma Engelm. Ridge-seeded Spurge. A. C. Herb.: New Yorktown, Kidder Co. 1320. Coll., Perrine.

Euphorbia maculata L. Milk Purslane. Spotted Spurge. This and others of the Spurge family will furnish teachers with good material for the study of a parasitic rust disease nearly always found upon its leaves. A. C. Herb.: Neche 651, Fargo.

Euphorbia dictyosperma F. & M. Reticulate-seeded Spurge. A. C. Herb.: Medora 653.

URTICACEAE. NETTLE FAMILY.

Ulmus Americana L. American Elm. White Elm. Water-Elm. This is recognized as the best shade tree in the United States.

It is artistically graceful in limb and foliage arrangement. The tree is hardy throughout the state, but demands a liberal supply of water. If this is given, or if the soil moisture is maintained through surface cultivation, it makes rapid growth. Found throughout the natural wooded areas of the state along river banks. A. C. Herb.: Fargo 654.

ULMUS FULVA Michx. Red or Slippery Elm. The inner bark is used as an official drug. See U. S. P. A. C. Herb.: Fargo 1233.

CELTIS OCCIDENTALIS L. Nettle Tree. Hackberry. Sugarberry. Found throughout the state with *Ulmus Americana* upon dryer soils. A smaller tree successfully grown for shade. A. C. Herb.: Fargo 655, Valley City. Univ. Herb.: Grand Forks.

HUMULUS LUPULUS L. Common Hop. Throughout the wooded regions of the state. Parent of the cultivated hop. Official drug. See U. S. P. A. C. Herb.: Medora 656, Minot, Fargo, Turtle Mts., Bismarck. Univ. Herb.: Grand Forks.

URTICA GRACILIS Ait. Slender Nettle. The plant grows two to six feet high from perennial roots giving a very large growth. It produces a quantity of long bast fibers, and as the stalks may be made to grow very slender, it may be found to be worthy of cultivation for fiber. A. C. Herb.: Bathgate 658, Lisbon, Jamestown, Rolla, Lake Metigoshe, Fargo, Towner. Univ. Herb.: Grand Forks.

LAPORTEA CANADENSIS Gaud. *Urticastrum divaricatum* (L.) Kuntze. Wood Nettle. This plant also produces a fair quality of fiber when retted and has been used for that purpose in Europe. A. C. Herb.: Neche 660, Fargo.

PARIETARIA PENNSYLVANICA Muhl. Pellitory. A. C. Herb.: Lisbon 1308. Coll., Fieldstad.

CUPULIFERAE. OAK FAMILY.

BETULA OCCIDENTALIS Hook. Coult. Man. Western Red Birch. There are a number of the birch trees native to the wooded areas of the state. The white or canoe birch in particular grows well in lawns, making a fine ornamental tree. A. C. Herb.: Turtle Mts. 661.

ALNUS INCANA Willd. Speckled Alder. Hoary Alder. Found in margins of streams and lakes. A. C. Herb.: Neche 663, Bathgate, Fargo.

CORYLUS AMERICANA Wats. Hazel-nut. Found in thickets in dry areas. May be used to advantage for lawn shrubbery. A. C. Herb.: Fargo 665, Ft. Totten, Turtle Mts. Univ. Herb.: Devil's Lake.

CORYLUS ROSTRATA Ait. Beaked Hazel-nut. A. C. Herb.: Rolla 668, Turtle Mts.

OSTRYA VIRGINICA Willd. American Hop-hornbean. Leverwood. A very hard, compact wooded tree of small size. A. C. Herb.: Fargo 669.

QUERCUS MACROCARPA Michx. Bur Oak. Mossy-cup Oak. Over-cup Oak. This is common throughout the wooded areas of the state. It may be successfully grown from the acorn, but it is difficult to make a success of transplanting. A. C. Herb.: Fargo 670, Lake Metigoshe, Bismarck, Valley City. Univ. Herb.: Grand Forks.

QUERCUS MACROCARPA DEPRESSA Engelm. Coult. Man. A smaller form of the last species. A. C. Herb.: Bottineau 672, Valley City 1067.

SALICACEAE. WILLOW FAMILY.

SALIX NIGRA Marsh. Black Willow. Found along water margins. A. C. Herb.: Fargo 780.

SALIX AMYGDALOIDES Anders. Peach-leaved Willow. A fair sized timber tree. Wood very light. A. C. Herb.: Jamestown 1078. Coll., Schmidt.

SALIX LONGIFOLIA Muhl. *Salix fluviatilis* Nutt. River-bank Willow. Sand-bar Willow. A good willow for embankments and other places where it is desired to prevent washing. A. C. Herb.: Medora, flats of Little Missouri 674, Buffalo, Jamestown, Rutland. Univ. Herb.: Grand Forks.

SALIX ROSTRATA Richardson. *Salix Bebbiana* Sarg. Bebb's Willow. A. C. Herb.: Rolla 675.

SALIX CANDIDA Fluegge. Hoary Willow. A. C. Herb.: Valley City 1355. Coll., Perrine.

SALIX CORDATA Muhl. Heart-leaved Willow. A. C. Herb.: Ft. Totten 676, Hope.

POPULUS TREMULOIDES Michx. American Aspen. Sometimes grown as a small shade tree. Not common. A. C. Herb.: Valley City 1328, Ransom Co. 1329. Coll., Perrine.

POPULUS GRANDIDENTATA Michx. Large toothed Aspen. Attains a height of 75 feet. A. C. Herb.: Neche 678.

POPULUS BALSAMIFERA L. Balsam Poplar. Tacamahac. Noted for its odorous buds. A. C. Herb.: Ransom Co. 1356. Coll., Perrine.

POPULUS MONILIFERA Ait. *Populus deltoides* Marsh. Cottonwood. Necklace Poplar. Carolina Poplar. Found throughout the state along streams and water courses. The most valuable tree in the state. Used successfully in tree culture upon all soils, thriving everywhere if the ground is kept cultivated. A. C. Herb.: Medora, flats of Little Missouri 680, Fargo.

CONIFERAE. PINE FAMILY.

JUNIPERUS COMMUNIS L. Juniper. A small tree on the buttes of the Bad Lands. It grows upon dry sterile banks. It would probably make a fair growth for ornamental purposes in most of the drier parts of the state. The tree furnishes the juniper berries of commerce and also the Oil of Juniper. See U. S. P. A. C. Herb.: Medora 681.

JUNIPERUS SABINA PROCUMBENS Pursh. *Juniperus Sabina* L. Shrubby Red Cedar. A small creeping cedar. Furnishes a volatile oil called Oleum Savin, used in medicine. A. C. Herb.: Bismarck, Haystack Butte 682, Medora 683.

JUNIPERUS VIRGINIANA L. Red Cedar. Savin. Found in large quantities and of fair size in Bad Lands near Medora. This tree furnishes the timber for the manufacture of lead pencils. A. C. Herb.: Medora 1038.

HYDROCHARIDACEAE. FROG'S-BIT FAMILY.

ELODEA CANADENSIS Michx. *Philotria Canadensis* (Michx.) Britt. Water-weed. Ditch-moss. Water Thyme. A. C. Herb.: LaMoure 684, Leeds 685.

ORCHIDACEAE. ORCHID FAMILY.

CORALLORHIZA MULTIFLORA Nutt. Large Coral-root. A. C. Herb.: Neche 686.

HABENARIA HYPERBOREA R. Br. Tall Leafy Green Orchis. Bogs and low places. A. C. Herb.: Ft. Totten 687, Hope.

HABENARIA LEUCOPHAEA Gray. Prairie White-fringed Orchis. A very handsome, rather rare plant. A. C. Herb.: Power 1203.

CYPRIPEDIUM CANDIDUM Muhl. *Cypripedium candidum* Willd. Small White Ladies' Slipper. A lowland plant. A. C. Herb.: Fargo 688, Rutland.

CYPRIDEDIUM PUBESCENS Willd. *Cypripedium hirsutum* Mill. Large Yellow Ladies' Slipper. A. C. Herb.: Rolla 1359. Coll., Perrine.

IRIDACEAE. IRIS FAMILY.

SISYRINCHIUM ANGUSTIFOLIUM Mill. Pointed Blue-eyed Grass. A good monocotyledon for class study in schools. A. C. Herb.: Fargo 689. Valley City, Sykeston, Jamestown, White Earth.

AMARYLLIDACEAE. AMARYLLIS FAMILY.

HYPOXIS ERECTA L. *Hypoxis hirsuta* (L.) Coville. Star-grass. A. C. Herb.: Fargo 691, Oakes. Univ. Herb.: Grand Forks.

LILIACEAE. LILY FAMILY.

SMILAX HERBACEA L. Carrion-flower. The foliage of this plant is large and artistic and will add beauty to any clump of foliage or shrubbery. It grows from heavy rootstocks. A. C. Herb.: Neche 693, Fargo, Turtle Mts., Valley City.

ALLIUM TRICOCCUM Ait. Wild Leek. A. C. Herb.: Fargo 761.

ALLIUM CERNUUM Roth. Nodding Wild Onion. Univ. Herb.: Willow City.

ALLIUM STELLATUM Ker. Prairie Wild Onion. A. C. Herb.: Bismarck 695, Valley City, Fargo. Univ. Herb.: Willow City.

ALLIUM RETICULATUM Fraser. *Allium reticulatum* Don. Fraser's Wild Onion. A. C. Herb.: Fargo 697, Jamestown, Bismarck, Valley City.

YUCCA ANGUSTIFOLIA Pursh. *Yucca glauca* Nutt. Bear Grass. A. C. Herb.: Bismarck 698, Mandan, Medora.

POLYGONATUM GIGANTEUM Dietr. *Polygonatum commutatum* (R. & S.) Dietr. Smooth Solomon's Seal. A. C. Herb.: Fargo 669. Univ. Herb.: Larimore.

ASPARAGUS OFFICINALIS L. Asparagus. Escaped from cultivation. A. C. Herb.: Fargo 700.

SMILACINA RACEMOSA Desf. *Vagnera racemosa* (L.) Morong. Wild or False Spikenard. A. C. Herb.: Rutland 783, Fargo.

SMILACINA STELLATA Desf. *Vagnera stellata* (L.) Morong. Star-flowered Solomon's Seal. A pretty plant of moist soil. A. C. Herb.: Neche 701, Turtle Mts. 702, Jamestown, Fargo. Univ. Herb.: Grand Forks.

MAIANTHEMUM CANADENSE Desf. *Unifolium Canadense* (Desf.) Greene. False Lily-of-the-Valley. Two-leaved Solomon's Seal. Found in moist woods. A. C. Herb.: Neche 704. Univ. Herb.: Grand Forks.

PROSARTES TRACHYCARPA Wats. Coult. Man. *Disporum trachycarpum.* (Wats.) B. & H. Rough-fruited Disporum. A. C. Herb.: Lake Metigoshe 703.

UVULARIA GRANDIFLORA Smith. Large-flowered Bellwort. A. dainty plant found in deep woods. A. C. Herb.: Bismarck 705, Fargo. Univ. Herb.: Grand Forks.

ERYTHRONIUM ALBIDUM Nutt. White Dog's-tooth Violet. White Adder's-tongue. Univ. Herb.: Grand Forks.

LILIUM PHILADELPHICUM L. *Lilium umbellatum* Pursh. Western Red Lily. One of the handsomest prairie flowers. A. C. Herb.: Fargo 706, White Earth 1290, Jamestown, Rolla, Valley City, Page. Univ. Herb.: Grand Forks.

TRILLIUM CERNUUM L. Nodding Wake-robin. Bath. In rich woods. A. C. Herb.: Fargo 707. Univ. Herb.: Grand Forks.

ZYGADENUS ELEGANS Pursh. Glaucous Zygadenus. A handsome prairie flower. A. C. Herb.: Valley City 708, Fargo 709, Rutland, Long Creek. Univ. Herb.: Grand Forks.

PONTEDERIACEAE. PICKEREL-WEED FAMILY.

HETERANTHERA GRAMINEA Vahl. *Heteranthera dubia* (Jacq.) MacM. Water Star-grass. This is a small form growing in mud. A. C. Herb.: Valley City 1309. Coll., Perrine.

COMMELINACEAE. SPIDERWORT FAMILY.

TRADESCANTIA VIRGINICA L. Spiderwort. The hairs upon the stamens of this plant when magnified show movement of protoplasm, hence valuable for class work in schools. A. C. Herb.: Rutland 710, Lisbon, Valley City, Hillsboro, Fargo. Univ. Herb.: Rugby Junction.

TRADESCANTIA BRACTEATA Small. Britt. & Br. Fl. Bracted Spiderwort. The plant is referred to this species with some hesitation. A. C. Herb.: Hillsboro 1336.

JUNCACEAE. RUSH FAMILY.

JUNCUS FILIFORMIS L. Thread Rush. This plant and other members of the family are lily-like in structure and sedge-like in aspect. Univ. Herb.: Grand Forks.

JUNCUS EFFUSUS L. Common Soft or Bog Rush. Univ. Herb.: Dunseith.

JUNCUS BALTICUS MONTANUS Eng. *Juncus Balticus* Willd. Baltic Rush. A. C. Herb.: Tower City 1017, Oakes, Bottineau, Medora. Univ. Herb.: Knox.

JUNCUS TENUIS Willd. Slender Rush. Yard Rush. A. C. Herb.: Neche 1019, Valley City 1020, Sykeston, Lisbon, Bottineau, Tower.

JUNCUS BUFONIUS L. Toad Rush. A. C. Herb.: Lisbon 1022.

JUNCUS NODOSUS L. Knotted Rush. A. C. Herb.: Neche 1023, Lake Metigoshe 1024, Rolla, Ft. Totten, Lisbon.

JUNCUS NODOSUS MEGACEPHALUS Torr. *Juncus Torreyi* Cov. Large-headed Rush. A. C. Herb.: Fargo 1026, Lisbon, Svea, Sully's Springs.

JUNCUS CANADENSIS J. Gay. Canada Rush. A. C. Herb.: Lake Metigoshe 1027.

TYPHACEAE. CAT-TAIL FAMILY.

TYPHA LATIFOLIA L. Broad-leaved Cat-tail. Very pretty as a house plant. A. C. Herb.: Lisbon 731, Fargo.

SPARGANIUM EURYCARPUM Engelm. Broad-fruited Bur-reed. A. C. Herb.: Fargo 712.

ARACEAE. ARUM FAMILY.

Arisaema triphyllum Torr. Jack-in-the-Pulpit. Indian Turnip. Clustered berries beautiful in autumn. Acrid bulbs said to be made edible by boiling. A. C. Herb.: Rutland 713, Fargo. Univ. Herb.: Grand Forks.

LEMNACEAE. DUCKWEED FAMILY.

Lemna trisulca L. Ivy-leaved Duckweed. Floating on ponds. Valuable for school studies in aquaria. A. C. Herb.: Kirk 715, Fargo.

Lemna purpusilla Torr. Minute Duckweed. A. C. Herb.: Turtle Mts. 1335.

ALISMACEAE. WATER-PLANTAIN FAMILY.

Alisma Plantago L. *Alisma Plantago-aquatica* L. Water Plantain. Growing in mud and shallow water. A. C. Herb.: Bottineau 716, Lisbon 717, Bismarck, Neche, Page, Fargo. Univ. Herb.: Grand Forks.

Sagittaria variabilis Engelm. *Sagittaria latifolia* Willd. Broad-leaved Arrow-head. Common in shallow water. A. C. Herb.: Fargo 718, Neche, Bismarck, Jamestown. Univ. Herb.: Grand Forks.

Sagittaria arifolia Nutt. Britt. & Br. Fl. Arum-leaved Arrow-head. Growing in shallow water. A. C. Herb.: Fargo 1334.

Sagittaria graminea Michx. Grass-leaved Sagittaria. A. C. Herb.: Fargo 720.

NAIADACEAE. PONDWEED FAMILY.

Triglochin palustris L. Marsh Arrow-grass. Found in bogs. A. C. Herb.: Valley City 744, Lisbon 1169.

Triglochin maritima L. Seaside Arrow-grass. A. C. Herb.: Towner 721, Tower 722. Univ. Herb.: Bottineau.

Potamogeton natans L. Common Floating Pondweed. A. C. Herb.: Lake Metigoshe 723.

Potamogeton perfoliatus L. Clasping-leaved Pondweed. A. C. Herb.: Fargo 724. Univ. Herb.: Bottineau.

POTAMOGETON PAUCIFLORUS Pursh. *Potamogeton foliosus* Raf. Leafy Pondweed. A. C. Herb.: Lisbon 1102. Coll., Fieldstad.

POTAMOGETON MUCRONATUS Schrad. *Potamogeton Friesii* Ruprecht. Pondweed. A. C. Herb.: Fargo 725.

POTAMOGETON PECTINATUS L. Fennel-leaved Pondweed. A. C. Herb.: Lake Metigoshe 727. Univ. Herb.: Bottineau.

ZANNICHELLIA PALUSTRIS L. Zannichellia. Horned Pondweed. In pools and ditches. A. C. Herb.: Ft. Totten 729.

NAIAS INDICA GRACILLIMA A. Br. *Naias gracillima* (A. Br.) Morong. Threadlike Naias. A. C. Herb.: Fargo 1338.

CYPERACEAE. SEDGE FAMILY.

CYPERUS ARISTATUS Rottb. *Cyperus inflexus* Muhl. In sandy soil. A. C. Herb.: Svea 1199. Coll., Fieldstad.

CYPERUS ENGELMANNI Steud. Engelmann's Cyperus. A. C. Herb.: Jamestown 1089. Coll., Schmidt.

ELEOCHARIS OVATA R. Br. Ovoid Spike-rush. A. C. Herb.: Fargo 1364.

ELEOCHARIS PALUSTRIS L. Creeping Spike-rush. A. C. Herb.: Wahpeton 975, Fargo 976. Univ. Herb.: Grand Forks.

ELEOCHARIS PALUSTRIS GLAUCESCENS Gray. A. C. Herb.: Valley City 1366. Coll., Perrine.

ELEOCHARIS ACICULARIS R. Br. *Eleocharis acicularis* (L.) R. & S. Needle Spike-rush. A. C. Herb.: Fargo 977. Univ. Herb.: Pleasant Lake.

SCIRPUS TORREYI Olney. Torrey's Bulrush. Wet places. A. C. Herb.: Tower City 984.

SCIRPUS LACUSTRIS L. Great Bulrush. Mat-rush. Growing in edges of lakes and in swamps. A. C. Herb.: Fuller's Lake 978. Univ. Herb.: Grand Forks.

SCIRPUS FLUVIATILIS Gray. River Club-rush. River Bulrush. A. C. Herb.: Fargo 979, Tower, Hope. Univ. Herb.: Grand Forks.

SCIRPUS ATROVIRENS Muhl. Dark Green Bulrush. Common in swamps. A. C. Herb.: Fargo 980, Turtle Mts. 981, Valley City, Lisbon, Jamestown.

SCIRPUS CAMPESTRIS Britt. Britt. & Br. Fl. Prairie Bulrush. A. C. Herb.: 983. Station unknown.

ERIOPHORUM GRACILE Koch. Slender Cotton-grass. Beautiful when in fruit. A. C. Herb.: Towner 982, Lisbon.

RHYNCHOSPORA CAPILLACEA Torr. Capillary Beaked-rush. In bogs. Univ. Herb.: Bottineau.

CAREX UTRICULATA Boott. Bottle Sedge. This and the following sedges are grass-like in aspect, and furnish a large percentage of the slough hay cut in the state. A. C. Herb.: Towner 1008.

CAREX RETRORSA Schwein. Retrorse Sedge. A. C. Herb.: Jamestown 985, Lisbon 1104.

CAREX HYSTRICINA Muhl. Porcupine Sedge. A. C. Herb.: Jamestown 1094. Coll., Schmidt.

CAREX HOUGHTONII Torr. Houghton's Sedge. In rocky soil. Univ. Herb.: Bottineau.

CAREX FILIFORMIS LATIFOLIA Boeckl. *Carex languinosa* Michx. Woolly Sedge. In swamps and wet meadows. A. C. Herb.: Valley City 1103, Tower, Devil's Lake.

CAREX TRICHOCARPA DEWEYI Bailey. *Carex trichocarpa* Muhl. Hairy-fruited Sedge. A. C. Herb.: Towner 989. Rutland, Hope.

CAREX TRICHOCARPA ARISTATA Bailey. *Carex aristata* R. Br. Awned Sedge. A. C. Herb.: Oakes 990, LaMoure, Rolla, White Earth.

CAREX STRICTA Lam. Tussock Sedge. Commonly used in making the "grass" binding twine. Rarely fruiting. A. C. Herb.: White Earth 1271. Coll., Haigh. Univ. Herb.: Grand Forks.

CAREX LONGIROSTRIS Torr. Long-beaked Sedge. Rather common on banks. A. C. Herb.: Valley City 1009, Sully's Springs in Bad Lands, Jamestown.

CAREX ASSINIBOINENSIS W. Boott. Britt. & Br. Fl. Assiniboia Sedge. In woods. Rare. A. C. Herb.: Neche 1016, Fargo 1165.

Carex flava L. Yellow Sedge. Univ. Herb.: Bottineau.

Carex flava viridula Bailey. *Carex viridula* Michx. Green Sedge. In bogs. A. C. Herb.: Lake Metigoshe 991.

Carex laxiflora Lam. Loose-flowered Sedge. In woods. A. C. Herb.: Fargo 1010.

Carex aurea Nutt. Golden-fruited Sedge. In wet meadows and woods. A. C. Herb.: Lake Metigoshe 992.

Carex Pennsylvanica Lam. Pennsylvania Sedge. Very common and blossoming very early. A. C. Herb.: Fargo 1012, Power, Svea. Univ. Herb.: Dickinson.

Carex stenophylla Wahl. Involute-leaved Sedge. In dry ground. A. C. Herb.: Verona 1013.

Carex alopecoidea Tuckerm. Foxtail Sedge. Apparently rather common. A. C. Herb.: Fargo 993, Rutland 994, Lisbon, Jamestown.

Carex marcida Boott. Coult. Man. Clustered Field Sedge. A. C. Herb.: Tower 996, Wahpeton 997, Medora, Lisbon.

Carex vulpinoidea Michx. Fox Sedge. Common on wet prairies. A. C. Herb.: Fargo 999, Leeds 1000, Lisbon, Jamestown, Lake Metigoshe.

Carex filifolia Nutt. Coult. Man. Thread-leaved Sedge. Found on buttes. A. C. Herb.: Medora 1307.

Carex echinata microstachys Boeckl. *Carex sterilis* Willd. Little Prickly Sedge. A. C. Herb.: Fargo 1191, Neche 1015.

Carex tribuloides Wahl. Blunt Broom Sedge. Univ. Herb.: Larimore.

Carex tribuloides Bebbii Bailey. More slender than the preceding. A. C. Herb.: Lake Metigoshe 1014.

Carex adusta Boott. Browned Sedge. A. C. Herb.: Lisbon 1339.

Carex foena Willd. Hay Sedge. Univ. Herb.: Bottineau.

Carex straminea Willd. Straw Sedge. Univ. Herb.: Devil's Lake.

Carex straminea brevior Dewey. *Carex festucacea* Willd. Fescue Sedge. Very common. A. C. Herb.: Fargo 1003, Valley City, Wahpeton, Hope, Davenport, Hillsboro, Rutland.

Carex sychnocephala Carey. Dense Long-beaked Sedge. Rare. A. C. Herb.: Lake Metigoshe 1106, Lisbon.

GRAMINEAE. GRASS FAMILY.

Spartina cynosuroides Willd. Fresh-water Cord-grass. Tall Marsh-grass. The chief hay producing grass of the Red River Valley. A. C. Herb.: Fargo 786, Bottineau 787, Tower, Page, Hillsboro, Davenport, Neche, Bismarck, Sykeston, Williston.

Spartina gracilis Trin. Coult. Man. Univ. Herb.: Medora.

Beckmannia erucaeformis uniflora Scribn. *Beckmannia erucaeformis* (L.) Host. Beckmannia. Slough-grass. Rattlesnake-grass. A. C. Herb.: Fargo 788, Bismarck, Long Creek in Ward Co.

Panicum sanguinale L. *Syntherisma sanguinalis* (L.) Nash. Large Crab-grass. Finger-grass. Sparingly naturalized. Bad weed in cultivated ground. A. C. Herb.: Fargo 975.

Panicum capillare L. Old Witch Grass. Tumble-weed. Very common. A. C. Herb.: Fargo 791, Devil's Lake, Bismarck. Univ. Herb.: Medora.

Panicum sp. A form gathered in Ransom Co., related to *Panicum capillare* but very delicate, quite glabrous, narrow leaves, spikelets three-quarters of a line long, with first and second scales about equal. A. C. Herb.: 1345. Coll., Perrine.

Panicum virgatum L. Tall Smooth Panicum. Switch-grass. Found in heavy growths on Missouri River Flats. A. C. Herb.: Fargo 792, Turtle Mts. 793, Medora, Tower, Bismarck, Davenport, Hope, Power. Univ. Herb.: Dickinson.

Panicum xanthophysum Gray. Slender Panicum. In meadows. A. C. Herb.: Wheatland 794, Davenport 870, Page, Rutland, Wahpeton.

Panicum latifolium L. *Panicum Porterianum* Nash. Porter's Panicum. A. C. Herb.: Jamestown 1245.

Panicum scoparium Lam. *Panicum Scribnerianum* Nash.

Scribner's Panicum. A. C. Herb.: Fargo 795. Univ. Herb.: Merrifield.

PANICUM DEPAUPERATUM Muhl. Starved Panicum. In dry places. A. C. Herb.: Jamestown 1244.

PANICUM CRUS-GALLI L. Barnyard Grass. Cockspur Grass. Very common in low wet soils. About as valuable for hay as millet. A. C. Herb.: Fargo 796, Wild Rice, Lisbon, Bismarck. Univ. Herb.: Church's Ferry.

SETARIA GLAUCA Beauv. *Ixophorus glaucus* (L.) Nash. Yellow Foxtail. Pigeon Grass. A very bad weed in cultivated ground. Sometimes cut for hay. A. C. Herb.: Fargo 798, Jamestown.

SETARIA VIRIDIS Beauv. *Ixophorus viridis* (L.) Nash. Pigeon Grass. Green Foxtail-grass. Differs from the preceding in its smaller grain. This and the last species probably reduces the yield of wheat in this state more than all other weeds combined. Thorough screening of seed grain will greatly reduce its capabilities to do injury. A. C. Herb.: Davenport 993, Fargo, Hope, Williston. Univ. Herb.: Willow City.

SETARIA ITALICA Kunth. *Ixophorus Italicus* (L.) Nash. Italian Millet. Hungarian Grass. Occasionally escaped. Larger with longer head than the preceding. A. C. Herb.: Fargo 799.

LEERSIA ORYZOIDES Swartz. *Homalocenchrus oryzoides* (L.) Poll. White Grass. Rice Cut-grass. Wet places. A. C. Herb.: Fargo 800.

ZIZANIA AQUATICA L. Wild Rice. Indian Rice. Water Oats. Reed. A. C. Herb.: Fargo 801, Wild Rice 878.

ANDROPOGON FURCATUS Muhl. Big Blue-stem. Forked Beard-grass. This and the next are very valuable as forage and hay in the Missouri River region. A. C. Herb.: Fargo 802, Neche, Bismarck, Medora, Minot, Devil's Lake. Univ. Herb.: Rugby Junction.

ANDROPOGON SCOPARIUS Michx. Broom Beard-grass. Little Blue-stem. A. C. Herb.: Bottineau 803, Sykeston, Fargo, Jamestown.

ANDROPOGON HALLII Hack. Hall's Beard-grass. Turkey-foot. A. C. Herb.: Ransom Co. 1340. Coll., Perrine. Univ. Herb.: Rugby Junction.

CHRYSOPOGON NUTANS Benth. *Chrysopogon avenaceus*

(Michx.) Benth. Indian Grass. A. C. Herb.: Towner 866, Fargo.

PHALARIS CANARIENSIS L. Canary-grass. Introduced. A. C. Herb.: Fargo 1155. Univ. Herb.: Willow City.

PHALARIS ARUNDINACEA L. Reed Canary-grass. The variety picta of this species is the well known Ribbon-grass cultivated for ornament. A. C. Herb.: Rutland 804, Turtle Mts. 805, Bismarck, White Earth, Tower, Sykeston.

HIEROCHLOE BOREALIS R. & S. *Savastana odorata* (L.) Scribn. Holy Grass. Seneca Grass. Vanilla Grass. Much used by Indians for making mats and boxes on account of the pleasant odor which it retains for a long time. A very bad weed in grain fields. Must be treated after the manner applied to Quack-grass in order to eradicate the creeping underground stems. A. C. Herb.: Fargo 806, Bismarck, Rolla, White Earth, Bathgate. Univ. Herb.: Grand

ARISTIDA PURPUREA Nutt. Purple Aristida. A. C. Herb.: Medora 909, Bismarck.

STIPA SPARTEA Trin. Porcupine Grass. This and the two following species are valuable native pasture grasses, but the awned seeds are detrimental to wool production and injurious to animals when in hay. The fruiting parts, "seeds", of this grass furnish admirable objects for nature-study in common schools. A. C. Herb.: Fargo 810, Sykeston, Wahpeton. Univ. Herb.: Inkster.

STIPA VIRIDULA Trin. Green Stipa. Feather Bunch-grass. A. C. Herb.: Fargo 811, Rutland 812, Valley City, Wahpeton, Sykeston. Univ. Herb.: Rugby Junction.

STIPA COMATA Trin. & Rupr. Western Stipa. Needle-and-Thread. A. C. Herb.: Rutland 808, Valley City 809, Lidgerwood. Univ. Herb.: Dickinson.

ORYZOPSIS MELANOCARPA Muhl. Black-fruited Mountain Rice. .A C. Herb.: Fargo 814, Neche.

ORYZOPSIS CUSPIDATA Benth. Coult. Man. *Oryzopsis cuspidata* (Nutt.) Vasey. Silky Oryzopsis. A. C. Herb.: Medora 940. Univ. Herb.: Bottineau.

MUHLENBERGIA SOBOLIFERA Trin. Rock Muhlenbergia. A. C. Herb.: Ward Co. 1258. Coll., Haigh.

MUHLENBERGIA GLOMERATA Trin. *Muhlenbergia racemosa* (Michx.) B. S. P. Marsh Muhlenbergia. Wild Timothy. A. C.

Herb.: Fargo 815, Hope 868, Neche, Valley City, Mandan, Towner, Wahpeton, Englevale. Univ. Herb.: Lake Girard.

MUHLENBERGIA MEXICANA Trin. Knot-root Grass. A. C. Herb.: Fargo 816.

PHLEUM PRATENSE L. Timothy. Herd's Grass. Introduced. A. C. Herb.: Fargo 817, Bismarck.

ALOPECURUS GENICULATUS ARISTULATUS Torr. *Alopecurus geniculatus* L. Marsh Foxtail. A. C. Herb.: Fargo 818, Bottineau, Page. Univ. Herb.: Devil's Lake.

SPOROBOLUS VAGINAEFLORUS Vasey. *Sporobolus vaginaeflorus* (Torr.) Wood. Sheathed Rush-grass. A. C. Herb.: Fargo 867.

SPOROBOLUS CUSPIDATUS Torr. Prairie Rush-grass. Carrion or Stink Grass. A. C. Herb.: Botineau 820, Minot, Ft. Totten, Sykeston, Leeds, Medora, Hope. Univ. Herb.: Medora.

SPOROBOLUS DEPAUPERATUS Vasey. *Sporobolus breviflorius* (Nutt.) Scribn. Short-leaved Rush-grass. A. C. Herb.: Towner 895, Jamestown. Univ. Herb.: Dickinson.

SPOROBOLUS HETEROLEPIS Gray. Northern Dropseed. A. C. Herb.: Wheatland 821, Harlem, Dawson, Bismarck, Grand Forks.

SPOROBOLUS CRYPTANDRUS Gray. Sand Dropseed. A. C. Herb.: Devil's Lake 864, Bismarck, Medora, Ft. Buford. Univ. Herb.: Medora.

SPOROBOLUS ASPERIFOLIUS Thurb. Rough-leaved Dropseed. A. C. Herb.: Dawson 918.

AGROSTIS ALBA L. Red-top. Fiorin. Herd's-grass. White Bent-grass. Introduced. A. C. Herb.: Hope 927, Davenport, Neche, Leeds, Dickinson, Bismarck.

AGROSTIS SCABRA Willd. *Agrostis hyemalis* (Walt.) B. S. P. Rough Hair-grass. Rough Bent. A. C. Herb.: Hope 925, Davenport, Harlem, Neche, Sykeston, Jamestown, Rolla.

CALAMAGROSTIS CANADENSIS Beauv. Blue-joint Grass. Produces a large amount of hay grass in low lands. A. C. Herb.: Turtle Mts. 942, Fargo, Lisbon, Bismarck, Grand Forks. Univ. Herb.: Devil's Lake.

CALAMAGROSTIS LANGSDORFII Trin. Langsdorf's Reed-grass. A. C. Herb.: Turtle Mts. 943.

CALAMAGROSTIS STRICTA Trin. *Calamagrostis neglecta* (Ehrh.) Gaertn. Narrow Reed-grass. Pony-grass. A. C. Herb.: Rutland 881, Turtle Mts., Fargo, Hope. Univ. Herb.: Bottineau.

CALAMAGROSTIS CONFINIS Nutt. Bog Reed-grass. A. C. Herb.: Rolla 860, White Earth 1281. Univ. Herb.: Minot.

CALAMAGROSTIS LONGIFOLIA Hook. *Calamovilfa longifolia* (Hook.) Hack. Long-leaved Reed-grass. Sand-grass. A. C. Herb.: Turtle Mts. 823, Hope 853, Bismarck, Medora. Univ. Herb.: Dickinson.

DECHAMPSIA CAESPITOSA Beauv. Tufted Hair-grass. Univ. Herb.: Willow City.

AVENA SATIVA L. Oats. Escaped. A. C. Herb.: Davenport 947. Univ. Herb.: Grand Forks.

AVENA FATUA L. Wild Oats. Distinguished from the cultivated oat by its darker colored grain and by both flowers of the spikelet bearing awns. A very bad weed in grain fields. The seeds usually fall early, thus keeping lands under cultivation thoroughly seeded from year to year. A. C. Herb.: Fargo 948, Hope, Valley City.

AVENA STRIATA Michx. Purple Oat. A. C. Herb.: Turtle Mts. 949.

DANTHONIA SPICATA Beauv. Wild Oat-grass. A. C. Herb.: Valley City 1342. Coll., Perrine.

SCHEDONNARDUS TEXANUS Steud. *Schedonnardus paniculatus* (Nutt.) Trelease. A. C. Herb.: Devil's Lake 888, Sykeston, Willow City.

BOUTELOUA OLIGOSTACHYA Torr. Grama-grass. Bunch-grass. Mesquite-grass. Muskit-grass. Buffalo-grass. This and the next species produce a large percentage of the native sod and westward furnish the chief pasturage of the great ranges. A. C. Herb.: Valley City 829, Lisbon 889, Bad Lands, Sykeston, Minot, Bismarck, Towner, Hope. Univ. Herb.: Minot.

BOUTELOUA RACEMOSA Lag. *Bouteloua curtipendula* (Michx.) Torr. Racemed Bouteloua. Side Oats. A. C. Herb.: Fargo 825, Lisbon, Medora. Univ. Herb.: Minot.

BUCHLOE DACTYLOIDES Engelm. *Bulbilis dactyloides* (Nutt.) Raf. Buffalo-grass. This is the real Buffalo-grass of the plains, a most valuable grass; but it is rapidly disappearing. It does not withstand continued pasturing. A. C. Herb.: Medora 875, Dickinson, Devil's Lake.

Phragmites communis Trin. *Phragmites Phragmites* (L.) Karst. Reed. A. C. Herb.: Turtle Mts. 826, Englevale, Devil's Lake, Jamestown. Univ. Herb.: Minnewaukon.

Koeleria cristata Pers. Koeleria. Prairie June-grass. A. C. Herb.: Rutland 827, Fargo, Jamestown, Sykeston, Valley City, Medora, Ft. Buford, Lisbon. Univ. Herb.: Dickinson.

Eatonia obtusata Gray. Blunt-scaled Eatonia. Early Bunch-grass. A. C. Herb.: Ft. Buford 855, Bismarck, Jamestown. Univ. Herb.: Dunseith.

Eatonia Pennsylvanica Gray. Univ. Herb.: Pleasant Lake.

Catabrosa aquatica Beauv. Coult. Man. Water Whorl-grass. A. C. Herb.: Rolla 959.

Eragrostis major Host. Strong-scented Eragrostis. Stink-grass. Introduced. A. C. Herb.: Dawson 863, Bismarck, Jamestown, Steele.

Eragrostis pursjiii Schrad. Southern Spear-grass. A. C. Herb.: Minot 917. Univ. Herb.: Medora.

Distichlis maritima Raf. *Distichlis spicata* (L.) Greene. Marsh Spike-grass. Salt-grass. In alkaline areas. A. C. Herb.: Devil's Lake 829, Sykeston 873, Tower, Church's Ferry, Mouse River. Univ. Herb.: Church's Ferry.

Dactylis glomerata L. Orchard Grass. Introduced. A. C. Herb.: Fargo 830, Bismarck.

Poa annua L. Low Spear-grass. Annual Meadow-grass. A. C. Herb.: Jamestown 1096. Coll., Schmidt. Univ. Herb.: Dickinson.

Poa compressa L. Wire-grass. Flat-stemmed Meadow-grass. English Blue-grass. Canadian Blue-grass. Introduced. A. C. Herb.: Fargo 832.

Poa laxa Haenke. Wavy Meadow-grass. Mountain Spear-grass. A. C. Herb.: Oakes 837.

Poa nemoralis L. Wood Meadow-grass. Northern Spear-grass. A. C. Herb.: Rutland 835, Ward Co. 1260, Rolla, Sykeston.

POA SEROTINA Ehrh. *Poa flava* L. False Red-top. Fowl Meadow-grass. Produces a heavy growth in wet hay lands. A. C. Herb.: Fargo 834, Turtle Mts. 836, Dickinson, Bismarck, Lidgerwood, Bathgate, Jamestown, Sykeston. Univ. Herb.: Willow City.

POA PRATENSIS L. June Grass. Kentucky Blue-grass. The grass commonly used in lawns. A. C. Herb.: Wahpeton 831, Rolla 862, Fargo.

POA ARIDA Vasey. Britt. & Br. Fl. Prairie Spear Grass. A. C. Herb.: Oakes 972.

POA BUCKLEYANA Nash. Britt. & Br. Fl. Bunch Red-top. A. C. Herb.: Ward Co. 1259. Coll., Haigh.

ATROPIS LAEVIS (Vasey.) Beal. Beal, Grasses N. A. II:577. *Poa laevis* Vasey. Possibly another species of Poa. Univ. Herb.: Dickinson.

GRAPHEPHORUM FLEXUOSUM Thurb. Coult. Man. *Redfieldia flexuosa* (Thurb.) Vasey. A. C. Herb.: Sand Hills, Ransom Co. 1345. Coll., Perrine.

SCOLOCHLOA FESTUCACEA Link. Fescue Scolochloa. Growing in marshes. Produces much coarse hay in old lake beds. A. C. Herb.: Fargo 974, Hope, Jamestown.

GLYCERIA GRANDIS Wats. *Panicularia Americana* (Torr.) MacM. Reed Meadow-grass. Tall Manna-grass. Rather tall grass, common in wet land, usually in shallow standing water. A. C. Herb.: Fargo 838, Hope, Lisbon, Jamestown, Valley City, Rolla.

GLYCERIA FLUITANS R. Br. *Panicularia fluitans* (L.) Kuntze. Floating Manna-grass. Commonly in water. A. C. Herb.: Fargo 973.

PUCCINELLIA AIROIDES (Nutt.) Wats. & Coult. Britt. & Br. Fl. *Glyceria distans* Wahl. Coult. Man. Slender Meadow Grass. In saline or alkaline soil. A. C. Herb.: Devil's Lake 956, Dickinson, Tower City, Rolla, Sykeston.

FESTUCA TENELLA Willd. *Festuca octoflora* Walt. Slender Fescue-grass. A. C. Herb.: Medora 903.

FESTUCA NUTANS Willd. Nodding Fescue-grass. A. C. Herb.: Fargo 960, Neche 961.

FESTUCA SCABRELLA Torr. Coult. Man. Bunch Grass. Fescue Grass. A. C. Herb.: Rolla 1363.

Festuca elatior L. Tall or Fescue Meadow-grass. Introduced. A. C. Herb.: Bismarck 1362. Univ. Herb.: Langdon.

Festuca elatior pratensis Gray. *Festuca elatior* L. Univ. Herb.: Langdon.

Bromus Kalmii Gray. Wild Chess. A. C. Herb.: Bottineau 967. Univ. Herb.: Bottineau.

Bromus ciliatus L. Fringed Brome-grass. Wood Chess. Very common. Seems to have no forage value. A. C. Herb.: Fargo 840, Bottineau, Towner, Minot, Bismarck, Wild Rice.

Bromus ciliatus purgans Gray. *Bromus ciliatus* L. A. C. Herb.: Fargo 839, Turtle Mts. 841. Univ. Herb.: Langdon.

Bromus unioloides (Willd.) H.B.K. Britt. & Br. Fl. Schrader's Brome-grass. Southern Chess. Escaped from cultivation. A. C. Herb.: Fargo 962, Jamestown.

Bromus inermis L. Beal, Grasses N. A. II:612. Smooth or Austrian Brome-grass. Introduced. This is the pasture and hay grass which has become so well known in this state in the last few years. It is destined to add greatly to the wealth of the state. A. C. Herb.: Fargo 1157.

Agropyrum repens Beauv. Couch-grass. Quitch-grass. Quack-grass. Introduced. Apt to be a troublesome weed. Spreading by rootstocks. The spelling of the generic name is now given as Agropyron in the newer botanies. Any one of the native Agropyrons is worthy of a better name with farmers than this species bears; eastward it is considered to be one of the most deterimental of weeds. A. C. Herb.: Bottineau 849, Lisbon, Leeds, Davenport. Univ. Herb.: Inkster.

Agropyrum repens glaucum (Desf.) Scribn. Britt. & Br. Fl. Larger and stouter than the preceding. Valued for its hay and pasture qualities westward. It has but few rootstocks; hence it is not weedy in character like last species. This should more properly be given a specific name. A. C. Herb.: Fargo 842, Valley City 843, Devil's Lake, Lisbon, Leeds, Ft. Buford, Page.

Agropyrum dasystachyum Vasey. Northern Wheat-grass. A. C. Herb.: Medora 910.

Agropyrum violaceum Lange. *Agropyron violaceum* (Hornem.) Vasey. Purplish Wheat-grass. A. C. Herb.: Ward Co. 1257. Coll., Haigh.

Agropyrum caninum R. & S. Awned Wheat-grass. Fibrous-rooted Wheat-grass. Shows good hay producing characters under cultivation. A. C. Herb.: Fargo 851, Rolla 918, Harlem, Lisbon, Sykeston, Leeds, Neche. Univ. Herb.: Sims.

Agropyrum tenerum Vasey. Awned Wheat-grass. Thrives well under cultivation. A good hay grass and seed producer. A. C. Herb.: Bottineau 845, Fargo, Hope, Lisbon, Towner, Medora, Sykeston. Univ. Herb.: Dickinson.

Agropyrum spicatum (Pursh) Scribn. & Sm. Britt. & Br. Fl. III:507. Western Wheat-grass. A. C. Herb.: Sykeston 914, Valley City, Fargo.

Hordeum jubatum L. Wild Barley. Squirrel-tail Grass. Foxtail. Flickertail Grass. A bad weed encroaching upon lawns and pastures. Of no agricultural value and injurious to cattle when fed as hay, the long sharp awns causing ulcerations. A. C. Herb.: Fargo 847, Valley City, Page Grand Forks, Bismarck, White Earth. Univ. Herb.: Minot.

Hordeum pratense Huds. *Hordeum nodosum* L. Meadow Barley. A. C. Herb.: Medora 968.

Elymus Virginicus L. Terrell-grass. Virginia Wild Rye. A. C. Herb.: Fargo 850, Wild Rice, Page, Hillsboro, Lisbon, Medora, Ft. Buford.

Elymus Canadensis L. Nodding Wild Rye. When seeded thickly upon the ground a heavy crop of good hay has been cut from this native grass. A. C. Herb.: Power 852, Lake Metigoshe, Minot, Devil's Lake, Williston, Medora. Univ. Herb.: Devil's Lake.

Elymus striatus Willd. Slender Wild Rye. A. C. Herb.: Valley City 898.

Elymus Macounii Vasey. Macoun's Wild Rye. A. C. Herb.: Devil's Lake 922, Ft. Buford, Bismarck, Fargo.

Asprella Hystrix Willd. *Hystrix Hystrix* (L.) Millsp. Bottle-brush Grass. A. C. Herb.: Fargo 1049, Valley City.

PTERIDOPHYTES. THE FERNS AND THEIR ALLIES.

This group of plants falls outside the limits assigned by our title, but as there are so few PTERIDOPHYTES in the state, those collected are listed below.

EQUISETACEAE. HORSETAIL FAMILY.

EQUISETUM ARVENSE L. Common Horsetail. Very common. A. C. Herb.: Fargo 1206. Univ. Herb.: Grand Forks.

EQUISETUM LIMOSUM L. *Equisetum fluviatile* L. Swamp Horsetail. A. C. Herb.: Valley City 1204.

EQUISETUM HYEMALE L. Scouring Rush. A. C. Herb.: Valley City 1361, Fargo.

EQUISETUM ROBUSTUM Brown. Stout Scouring-rush. A. C. Herb.: Fargo 1205.

FILICINAE. FERN FAMILY.

CYSOPTERIS FRAGILIS Bernh. Bladder Fern. Brittle Fern. A very delicate pretty plant. As a potted plant it produces a beautiful dense foliage. A. C. Herb.: Jamestown 1071. Coll., Schmidt. Spiritwood Lake 1021. Coll., Perrine. Bismarck.

ONOCLEA STRUTHIOPTERIS Hoffm. Ostrich Fern. A very handsome, tall fern, which may be potted and used for interior decoration. Along rivers. A. C. Herb.: Neche 1207, Fargo.

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JUL 29 1901

NORTH DAKOTA AGRICULTURAL COLLEGE.

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Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 47.

HUMUS AND SOIL NITROGEN.

CLIMATIC STUDIES WITH WHEAT, OATS AND CORN.

BROME AND TIMOTHY COMPARED.

AUSTRIAN BROME HAY.

BY

E. F. LADD.

Any farmer, teacher or student in the state can have this Bulletin mailed to his address, free of charge, upon application.

Fargo, North Dakota, U. S. A.
March, 1901.

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HUMUS AND SOIL NITROGEN.

BY E. F. LADD.

The first essential for successful agriculture is a fertile soil. If a soil is not by nature endowed with the elements of fertility, then the lacking constituents must be supplied in order to insure a maximum crop. Hence a knowledge of the chemistry of soil and of the feeding capacity of plants is an indispensable qualification for the successful farmer. Differences in soils and climates make necessary, different methods of soil treatment for different parts of the country. A region with an annual rainfall of 40 inches will, naturally, require methods unlike those necessary for a region of 20 inches per year. It is very probable that conditions of soil which prevail and are most satisfactory in Rhode Island or North Carolina might not be suitable for the conditions existing in North Dakota. It is likewise quite possible that the available plant food in these different soils may be found to exist in different forms. Humus, in these soils, may serve quite different purposes and thus it may have different values.

Before the time of Liebig, humus was considered the sole plant food. With the overthrow of the "humus theory", all was changed, and the organic matter of the plant was properly recognized as being derived from the atmosphere. Is it not possible that, in the overthrow of the humus theory, we failed to assign to humus the place to which it is justly entitled to in agriculture? What part does humus play in transforming the mineral constituents of the soil into available plant food? How does humus affect the physical condition of the soil and its water holding capacity? What part does humus and organic matter play in supplying nitrogen to the soil? We may even ask whether we, with a correct knowledge of humus might not be able so to regulate our methods of agriculture as to dispense with a considerable portion of the commercial fertilizers now so largely employed? The answers to all these questions come very slowly, but the field of work offers many inducements to investigators who are willing to undertake the difficult task of investigating Nature's methods of enriching the soil.

For the past nine years I have devoted a part of my time, during the summers, to lines of research in the chemistry of the soil, and particularly to the study of humus. Each year's work seems to throw new light on the problem, and to lead me to the belief that humus, at least in regions of low annual rainfall, like the Dakotas, plays a more important role in agriculture, than has generally been ascribed to it.

The data presented in this bulletin are in continuation of those published in previous bulletins, Nos. 24-32 and 35. In these earlier bulletins I attempted to show that there exists a relation between the humus and the amount of mineral matter, phosphates, potash, etc., extracted from the soil together with the humus by means of a 4 per cent. ammonia solution, and that these mineral products were in combination with the humus. It was also shown that as the humus decreased, the soils became less productive, less retentive of moisture and inferior in physical quality; while, on the other hand, it was found that an increase in the percentage of humus was accompanied not only with an increase, in percentage, of phosphoric acid, extracted with the humus, but also with a greater productivity of the soil.

This relative increase in humus and phosphoric acid is shown in the following table:

POUNDS PER FOOT ACRE.

	Humus in the Soil.	Phosphoric Acid With Humus.
1891	172,537	2,548
1894	219,945	2,933
1898	253,483	3,769

The above results indicate, that as the humus increased, the amount of phosphoric acid, extracted with the humus, also increased. That as the humus increases, it seems to cause portions of the phosphoric acid, till then existing in an insoluble form, to become transformed into a soluble form, and, thus, presumably, to become more readily available as plant food. The same is true as regards the potash, lime and other soil constituents.

During the past year our work has been continued along the same lines, but special attention has been given to the nitrates and soil moisture, the results of which we present in the following pages.

SOIL NITRATES AND NITRITES.

In our investigation of soil humus, organic matter, and the relation of humus to the available plant food and the conserving of soil moisture, some studies were made upon the nitrates and nitrites in different soils. This work was begun in 1899 and soils from the following plots were under examination.

Plot 0. A small parcel of land in the horticultural garden, left in bare summer fallow.

Plot No. 2. This field had been in wheat continuously since 1883.

Plot No. 11. In wheat continuously from 1883 to 1891. In 1892, green manured; 1893-'95, in wheat; 1896, green manured; and 1897-1899, in wheat.

Plot No. 16. In wheat continuously from 1883 to 1891. In 1892, timothy and clover; 1894, meadow-land. 1895-1896, in wheat; in 1897, barley; in 1898, wheat; and in 1899, timothy and clover.

Plot No. 17. Continuously in wheat 1883-1892; in 1893, in clover; in 1895-1896, wheat; 1897, barley; in 1898, wheat; and, in 1899, clover.

Plot No. 18. Wheat continuously 1883-1891; in 1892, in peas; in 1893, in wheat; in 1894-1895, clover; also in 1896-8, wheat; and in 1899, peas.

Plot No. 25. Wheat continuously since 1883.

Plot No. 27. Wheat continuously 1883-1892; 1893, timothy. 1894-'95-'96-'97, wheat; and in 1898-'99, timothy.

Plot No. 29. From 1883 to 1891, wheat; 1892, flax; 1893, fallow; 1894 to 1895, wheat; 1896, flax; 1897, fallow; and in wheat in 1898-1899.

Plot No. 30. Native prairie soil.

The following table shows the per centage of moisture contained in the soils at date of sampling, and the number of colonies of ordinary bacteria and the anaerobic bacteria developed from one-tenth gram of soil. In the last two columns we have given the pounds of nitrates and nitrites at the several depths. Our results are, for easy comparison, expressed in pounds per acre for a depth of one foot, using each time an average weight of 3,142,800 pounds. per acre as the weight of an acre of soil to the depth of one foot.

PLOT O, SAMPLED JULY 21.

Depth of Sample.	Colonies of Bacteria. Ordinary.	Colonies of Bacteria. Anaerobic.	Per cent Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
3 inches	30,200	1,009	30.40	415.9	8.2

6 inches	*	*	32.26	415.9	5.1
12 inches	*	*	25.57	234.3	6.1
18 inches	30,000	*	24.33	196.6	3.2
24 inches	30,000	*	25.47	430.9	4.1
36 inches	30,000	*	23.10	674.9	5.3
48 inches	15,000	*	22.96	316.3	6.1
60 inches	9,000	300	21.95	395.3	1.9
72 inches	7,509	2,000	21.54	247.0	2.9
84 inches	6,000	700	23.05	293.9	*

* Trace.

PLOT NO. 2, AUGUST 7.

Depth of Sample.	Colonies of Bacteria.		Per Cent. Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
	Ordinary.	Anaerobic.			
3 inches	17,480	1,942	9.91	166.1	0.8
6 inches	10,020	3,360	14.66	235.3	1.1
12 inches	1,360	**	15.24	228.4	1.8
24 inches	1,020	**	16.33	84.1	1.5

** None.

PLOT NO. 11, AUGUST 7.

Depth of Sample.	Colonies of Bacteria.		Per Cent. Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
	Ordinary.	Anaerobic.			
3 inches	10,800	2,160	14.14	263.6	1.75
6 inches	26,100	3,281	15.70	210.8	5.6
12 inches	9,180	2,280	16.00	247.1	2.9
24 inches	2,260	3,765	17.95	100.1	*

* Trace.

PLOT NO. 16, AUGUST 1.

Depth of Sample.	Colonies of Bacteria. Ordinary.	Colonies of Bacteria. Anaerobic.	Per Cent. Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
3 inches	52,250	6,456	15.22	102.8	1.5
6 inches	40.740	3,060	16.18	122.5	0.6
12 inches	21,600	2,400	16.94	97.3	1.0
24 inches	31,080	7,453	15.54	108.6	1.0

PLOT NO. 17, AUGUST 1.

Depth of Sample.	Colonies of Bacteria. Ordinary.	Colonies of Bacteria. Anaerobic.	Per Cent. Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
3 inches	46,200	4,863	14.91	125.6	1.0
6 inches	38,600	9,533	15.33	98.8	2.2
12 inches	33,440	512	15.74	125.5	5.3
24 inches	6,670	1,112	14.00	259.0	1.2

PLOT NO. 18, AUGUST 3.

Depth of Sample.	Colonies of Bacteria. Ordinary.	Colonies of Bacteria. Anaerobic.	Per Cent. Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
3 inches	20,200	*	17.17	143.7	0.7
6 inches	4,160	*	16.70	131.8	1.1
12 inches	1,600	*	17.13	127.6	0.9
24 inches	9,000	*	16.64	127.6	0.8

* Trace.

PLOT NO. 25, AUGUST 11.

Depth of Sample.	Colonies of Bacteria.		Per Cent. Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
	Ordinary.	Anaerobic.			
3 inches	13,760	362	14.82	217.9	1.0
6 inches	2,820	1,410	14.88	204.4	1.6
12 inches	17,400	1,933	14.15	156.7	1.3
24 inches	2,800	3,400	13.13	175.5	0.7

PLOT NO. 27, AUGUST 11.

Depth of Sample.	Colonies of Bacteria.		Per Cent. Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
	Ordinary.	Anaerobic.			
3 inches	45,180	8,219	13.62	169.4	1.0
6 inches	8,600	200	16.32	82.5	0.6
12 inches	1,440	0	17.50	140.5	0.5
24 inches	9,900	0	17.00	91.8	0.5

PLOT NO. 29, AUGUST 11.

Depth of Sample.	Colonies of Bacteria.		Per Cent. Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
	Ordinary.	Anaerobic.			
3 inches	24,270	6,067	15.10	286.2	1.3
6 inches	9,000	1,500	17.82	91.7	0.5
12 inches	13,350	6,575	14.34	75.3	0.6
24 inches	3,080	8,080	16.20	100.3	0.4

PLOT NO. 30, AUGUST 15.

Depth of Sample.	Colonies of Bacteria. Ordinary.	Colonies of Bacteria. Anaerobic.	Per Cent. Soil Moisture.	Nitrates Pounds Per Acre.	Nitrites Pounds Per Acre.
3 inches	31,750	3,968	15.02	86.3	0.4
6 inches	17,500	1,010	14.43	89.3	0.8
12 inches	13,350	6,575	14.34	75.3	0.6
24 inches	1,500	7,500	13.31	90.4	0.6

These results show a very wide range in the number of colonies of bacteria in the first three inches ranging from 10,000 in plot No. 11 to 52,000 in No. 16, while for the Anaerobic bacteria the range was from less than 400 colonies in plot 25 to more than 8,000 in plot 11.

An attempt was also made, though with poor results, to determine the colonies of nitrifying bacteria. In plot O a close estimate was made of the number of colonies developed by the method usually employed with results as below.

Plot O, July 21. Soil Depth.	Colonies. Nitrifying Bacteria.
3 inches	2,300
6 inches	2,300
12 inches	600
18 inches	200
24 inches	10
36 inches	None
48 inches	None
60 inches	None
72 inches	None
84 inches	None

From the above it will be seen that in the bare summer fallowed land no nitrifying bacteria were developed from soil taken at a greater depth than 24 inches. It may even be questioned whether those found below eighteen inches were not accidental since so few were found.

A question not infrequently raised is whether there is in reality much actual loss of nitrates in our level prairie county. An inspection of the results found for plot O shows that there were in the first six inches 415 pounds of nitrates per foot acre, while for the second six inches there were 234 pounds per foot acre. At a depth of three feet was found the largest amount, 675 pounds per foot acre, while at a depth of seven feet were found 294 pounds, or more than in the second six inches per foot acre. Now, a study of the nitrifying bacteria in this same soil failed to reveal the presence of nitrifying germs at a greater depth than eighteen inches; it certainly revealed none below two feet, while, the most of these germs, as would be expected, were found in the first foot of soil where the conditions are favorable for their development. In the first six inches, were found 85 per cent. of the nitrifying germs. It is evident, then, that the nitrates found at a greater depth than eighteen inches have migrated from near the surface. How much beyond a depth of seven feet nitrates were to be found, we do not know; nor are we certain as to the extent of their lateral movements where the water table is frequently less than seven feet below the surface. At this depth the nitrates are beyond the reach of any plant roots, and it is evident the loss of nitrates from our soils, where these are not properly managed, must be considerable.

During 1900, the soil studies of the preceding year were continued, and, inasmuch as the season was an exceptional one as regards climatic conditions, many of the results in relation to plant growth and soil fertility, are particularly interesting and instructive.

DESCRIPTION OF PLOTS EXAMINED IN 1900.

Plot 2. Wheat continuously.

Plot 3. Wheat, four years; timothy, two years. Present season the second in timothy.

Plot 5. Wheat, three years; corn, one year. Present season, in corn.

Plot 6. Wheat, three years; corn, one year; and corn, manured with rotted stable manure. Corn, present season.

Plot 17. Wheat, one year; clover, two years; wheat, two years; barley, one year. Present season, second year of clover. Plowed before July 14th, when sample was taken.

Plot 18. Wheat, three years; peas, one year; wheat, one year;

clover. two years. Present season, wheat after peas.

Plot 26. Wheat, three years; fallow, one year. Present season, fallow. Plowed before July 14th, date of sampling.

Plot 28. Wheat, four years; timothy, three years. Present season, in timothy.

Plote 35. Wheat, one year; flax, one year; corn, one year. Present season, wheat after corn preceded by flax.

Plot A. Summer fallowed soil in horticultural grounds; had been plowed previous to taking sample, July 14th.

Plot B. A field that had been in general farm crop; last year in oats, the present season put in wheat, but from lack of rain and growth of weeds re-plowed and summer fallowed.

Plot C. Virgin prairie.

Plot D. A piece of land like plot 2, but had been manured and had produced a crop of corn in 1899. The present season, in wheat.

The following table gives number of pound of nitrates and nitrites in each acre of the soil for the first six inches and for the second six inches:

POUNDS PER ACRE.

Date Sampled.	Plot.	Nitrates.		Nitrites.	
		1st 6 inches.	2nd 6 inches.	1st 6 inches.	2nd 6 inches.
May 4	2	75.40	28.78	1.71	1.33
May 30	2	28.75	25.14	1.74	*
July 14	2	48.64	27.03	0.89	0.54
July 30	2	23.97	23.40	0.57	0.44
May 4	3	23.28	70.21	1.55	*
May 30	3	36.63	39.76	1.11	1.04
July 14	3	58.32	42.73	1.11	*
July 30	3	54.97	20.87	0.88	*
May 4	5	57.18	32.42	0.95	1.40
May 30	5	70.28	69.17	*	1.08
July 14	5	126.51	83.08	1.58	1.04
July 30	5	65.18	36.02	0.54	1.11
May 4	6	70.21	73.12	3.76	1.42

May 30	6	113.96	53.14	1.39	3.80
July 24	6	45.16	60.82	1.27	1.55
July 30	6	27.48	24.51	1.88	0.92
May 4	17	40.55	40.36	3.89	2.28
May 30	17	41.43	65.91	2.88	2.02
July 14	17	70.28	55.48	1.87	2.66
July 30	17	81.09	158.14	6.45	2.51
May 4	18	197.68	104.53	1.14	2.87
May 30	18	225.89	191.67	1.80	1.96
July 14	18	36.78	82.27	1.45	1.36
July 30	18	37.51	23.25	0.92	1.20
May 4	26	97.29	46.14	0.85	3.18
May 30	26	50.54	17.33	0.79	0.70
July 14	26	26.57	22.64	1.88	0.60
July 30	26	39.88	21.19	1.04	0.73
May 4	28	272.48	26.22	1.17	2.22
May 30	28	107.16	28.91	1.36	1.39
July 14	28	52.69	29.54	1.61	1.55
July 30	28	36.56	25.39	1.20	0.57
May 4	35	173.29	160.13	6.23	1.30
May 30	35	80.56	90.17	2.81	1.68
July 11	35	55.00	27.07	1.89	0.85
July 30	35	35.93	26.06	3.61	2.59
May 4	A	158.14	96.69	1.01	*
May 30	A	80.56	81.60	3.89	2.81
July 14	A	44.78	47.31	0.66	3.24
July 30	A	158.14	114.99	0.89	3.64
May 4	B	98.84	101.21	*	*
May 30	B	66.58	47.73	2.53	1.71
July 14	B	95.11	30.71	2.27	3.42
July 30	B	100.38	33.27	1.14	0.92

May 30	C	20.91	14.04	*	*
May 14	C	16.95	21.35	*	*
July 14	30	129.07	44.53	3.18	0.64
July 14	D	76.67	28.42	*	*
July 30	D	40.02	36.63	0.70	0.47

* Trace.

In order to show the condition of the soil later in the season and in connection with some other work, samples of soils were taken from a few plots October 19th.

POUNDS PER ACRE.

Plot.	Nitrates.			Nitrites.		
	1st foot.	Bottom 2nd foot.	Bottom 3rd foot.	1st foot.	Bottom 2nd foot.	Bottom 3rd foot.
2	71.2	47.4	24.6	2.7	1.8	1.6
5	102.6	19.4	19.4	2.8	1.8	1.7
18	118.6	124.8	63.2	2.8	0.8	0.8
35	88.3	100.9	64.7	4.1	1.0	1.0
A	126.5	105.4	21.6	3.8	2.4	1.1
C	20.6	20.6	22.1	3.5	1.9	1.1

It is interesting to note the small amount of nitrates present in the prairie sod as compared with cultivated soils. The laregst amount of nitrates was found in plot 18, where wheat had followed peas. In the bare summer fallow, plot A, also, there is is large amounts of nitrates. When Nature is left to herself, as in native soil, there remain small quantities of nitrates; for, the land, freezing in the fall, affords little chance for loss of soil-nitrogen by washing out of the ground.

It will be interesting and instructive to determine the amount of nitrates in these soils in the spring after the rains, and thus to determine what changes take place, and to what extent nitrogen is lost from the soil in the form of soluble nitrates.

SOIL NITROGEN.

The following table shows the per cent. of nitrogen in the first and in the second six inches of soil, also the pounds of nitrogen per acre calculated to the depth of one foot, from the above data.

PER CENT NITROGEN.

Date.	Plot.	1st 6 inches.	2nd 6 inches.	Pounds per acre.
May 4	2	.50	.39	13,916
May 30	2	.46	.36	12,967
July 14	2	.42	.28	11,070
July 30	2	.44	.35	13,284
May 4	3	.49	.35	12,651
May 30	3	.49	.46	14,865
July 14	3	.48	.20	10,753
July 30	3	.44	.35	13,284
May 4	5	.41	.24	12,018
May 30	5	.41	.43	13,284
July 14	5	.39	.22	9,805
July 30	5	.44	.40	13,284
May 4	6	.42	.36	12,335
May 30	6	.50	.43	14,549
July 14	6	.44	.26	11,070
July 30	6	.46	.27	11,386
May 4	17	.50	.49	15,498
May 30	17	.50	.51	15,814
July 14	17	.55	.50	16,763
July 30	17	.53	.51	16,446
May 4	18	.46	.48	14,865
May 30	18	.49	.49	15,498
July 14	18	.51	.46	15,498
July 30	18	.52	.41	14,549
May 4	26	.48	.39	13,916
May 30	27	.44	.41	13,600
July 14	26	.45	.29	11,702
July 30	26	.41	.26	12,335

May 4	28	.45	.42	13,916
May 30	28	.45	.47	14,916
July 14	28	.42	.44	13,600
July 30	28	.43	.26	13,916
May 4	35	.44	.37	12,651
May 30	35	.43	.42	13,284
July 14	35	.48	.30	12,335
July 30	35	.41	.27	10,753
May 4	A	.43	.49	14,549
May 30	A	.45	.44	13,917
July 14	A	.39	.41	12,651
July 30	A	.44	.41	13,284
May 4	B	.43	.28	11,386
May 30	B	.44	.32	12,018
July 14	B	.42	.25	10,753
July 30	B	.39	.23	9,805
May 30	C	...	...	......
July 14	C	.51	.30	12,967
July 30	C	...	...	......
July 14	D	.46	.22	10,753
July 30	D	.42	.31	11,386

This last table is particularly interesting, as showing duplicate results for nitrogen obtained from samples taken out the same field at different times. Again there is a relationship to be traced to different methods of cropping and cultivation. It is noticeable that these changes come almost wholly in the second six inches of soil.

ORGANIC MATTER AND HUMUS IN THE SOILS.

The percentage of humus was determined from the soil samples taken July 14th with results as follows:

PERCENTAGE OF ORGANIC MATTER AND OF HUMUS.

	First Six Inches.		Second Six Inches.	
No. of Plot.	Organic Matter.	Humus.	Organic Matter.	Humus.
2	15.59	6.06	12.46	4.80
3	16.91	6.44	13.14	3.08
5	15.06	4.95	12.99	2.48
6	15.77	4.47	10.42	4.68
17	18.34	7.82	16.11	4.49
18	16.01	6.15	13.36	6.01
26	17.00	6.06	12.27	4.73
28	15.32	5.14	12.87	4.75
35	16.24	6.15	12.52	4.30
A	15.98	5.62	18.93	6.49
B	16.75	5.15	10.69	1.70
C	26.25	4.77	15.89	3.53
D	17.45	5.14	12.51	3.65

The above table presents some particulrarly interesting results for the soils from the several plots. The highest amounts of organic matter and of humus are found in plot 17, which is in the second year of clover. The highest per cent. of organic matter for the second six inches is also found in the same plot, excluding plot A for reasons to be considered later. The per cent. of humus in the second six inches is not so high as in some of the plots in cultivation.

Plot B shows that the surface, to a depth of six inches, is well supplied with both organic matter and humus, but that the second six inches, contains a small per cent. of organic matter, and only one and seven-tenths per cent. of humus. This field has been continuously cropped in grains since 1883. The past season the land was put into wheat, but so poor was the growth of wheat, and so abundant were the weeds, that the crop was plowed under and the land was allowed to remain fallow. In the case of plot 6, in corn the present season, the application of well rotted manure has maintained a liberal supply of organic matter in the first six inches. But the amount of organic matter in the second inches is the lowest in the series. Forty-five per cent. of this amount is in the form of humus. This leaves but a small reserve to draw from.

Yet a high water content has, by thorough cultivation, been maintained in the surface soil in the driest time of the past summer.

In 1900, plot 2 yielded approximately four bushels of wheat per acre, and plot D 28 bushels. Plot 2 has been in wheat continuously since 1883, and probably longer. Plot D has been in crop rotation, general farm experiments since 1893 and having corn upon the land in 1899. The surface soil contains a large per cent. of organic matter, but less humus than plot 2. The corn crop would not perhaps add, to a perceptible degree, more organic matter to the soil than a wheat crop would add. The cultivation of corn in 1899 tended, as shown plainly in the handling of the samples, to conserve the soil moisture for the 1900 crop and to put the land in better physical condition. It furthermore tended to put the soil in better chemical condition, as demonstrated by the total amount of organic matter, and the amount of nitrates, as shown in preceding tables. On the 14th of July, samples of soil from plots 2, 6, and D, were taken and the moisture determined with results as below:

PER CENT. OF WATER.

Plot.	First Six Inches.	Second Six Inches.
2	10.40	13.50
6	.....	23.60
D	22.50	22.00

In plot 6, no sample was taken for the first six inches, as cultivation had so loosened the soil as to make a determination of the moisture of little value. These results would seem to indicate very clearly a cause for the difference between the results obtained from plots 2 and D. Plot 6 shows how moisture was by cultivation being conserved in the soil during a period of great drouth. It also accounts, in part, for the existence of more moisture in D, than in plot 2, since D was in corn in 1899.

Plot A is not in a normal condition. A dirt storm, a few years ago, covered the ground to a depth of six to eight inches, with drifted soil from cultivated land located the other side of the hedge. This probably accounts for the condition which otherwise seems unexplainable.

The value of leguminous plants, clover and peas, as soil enrichers are again manifest in the results for plot 18, where clover and peas enter into the system of rotation along with the wheat. Wheat in 1900 followed peas in 1899, but clover has not been on the ground since 1894. Here we have a good per cent. of organic matter in the second six inches of soil, and the maximum per cent. of humus. It will further be observed tnat the amounts of nitrates in the first and second six inches was, on May 30th, 226 and 192 pounds respectively, or, greater than that of any other plot in the series. The amount of nitrates in the second six inches was likewise more than in the corresponding depth of any other plot under examination—a fact which shows the fertile condition of the soil.

We have thus far refrained from discussing the chemical properties of plot 2. There are the series of four check plots, Nos. 1 and 2, and Nos. 24 and 25. We had selected Nos. 2 and 24 for chemical study, but the wheat failed so completely, and the weeds were so abundant, that the department of agriculture found it necessary to cancel the order of the experiment and to cause the land in plot 24 to be cleaned from weeds. The land was plowed and cultivated during the season. Unfortunately, the soil samples taken in the early season were not preserved as they should have been. Plot Nos. 1 and 2 have never given results in the past, wholly in accord with the results from the duplicate checks, Nos. 24 and 25. Plots 1 and 2 are located on the opposite side of the hedge and not far from A, while plots 24 and 25 are close by plot B. Further experiments are planned for testing the uniformity of the plots at the two ends of the series.

CHEMICAL COMPOSITION OF SOME MANURES.

In a previous publication from this Station, we have considered the properties of humus and its power to retain moisture. Experiments, made during the past year, upon composted manure, will aid in throwing additional light on this very important question. Mixed manures, containing considerable straw, from the cow and horse barn, are drawn out daily as produced and put in large piles. In building the piles, the loaded teams drive over the entire pile, thus compacting the manure. One long pile is made each season; the piles average about five feet high and perhaps twelve feet wide at the base. Under these conditions, the manures do not seem to heat or "fire fang", but are gradually converted into good compost.

It should be borne in mind that the average rainfall is less than 20 inches, and that as a general rule, we have little or almost no snow during the winter. These circumstance prevent the loss from washing which is sustained in regions of heavy rainfall. We have examined manure in three piles, drawn out in 1896, 1897 and

1898 respectively. These piles were sampled on June 26th, from the centers and tops, at a depth of two feet. The per cent. of water which they contained at date of sampling was as follows:

Compost for.		Per Cent. of Water.
1896	....	65.43
1897	....	69.53
1896	....	77.20

These manures were not made wet by rainfall; for, the total rainfall, including snow, from January 1st to June 26th, amounted to only 6.38 inches, and of this only 1.53 inches fell in the month of June. Moreover, the last rain preceding the sampling was on June 19th and 20th, when the total fall was 0.55 inch, an amount not enough to wet through the undecayed strawy manure covering the piles. An analysis of the dry matter of these manures is shown by the following table.

ANALYSIS OF DRY MATTER OF COMPOST.

	Per Cent.		
	1896	1897	1898
Organic Matter	52.25	70.40	79.49
Mineral Matter	47.[illegible]	29.60	20.51
Nitrogen	2.52	2.23	2.17
Humates (Extractive Matter)	14.17	16.27	19.24
Humus	10.81	12.47	14.36
Nitrates	0.	0.	0.
Nitrites	0.	0.	0.

Here we have piles of composted manure exposed to all the climatic changes during a period of great drouth, when many soils, not well cultivated, contained so little moisture that seed failed to germinate, and when grass fields were parched and seared. In a period of such drouth more than three-fourths of the entire pile was water. The tenacity with which this humus, and partly decayed matter held their water supply, and did not yield it to the dry air or surrounding soil, is well shown in this instance.

This confirms what we have pointed out in earlier publications regarding the influence, in the soil, of humus, for holding moisture when the physical condition of the soil is maintained in good condition.

The absence of nitrifying organisms in the manure piles, is indicated by the complete absence of either nitrates or nitrites. Manures that had remained in the piles for more than two years, were inferior to those for a shorter period. The loss of decaying organic matter, and of humus has been very heavy, for the manure drawn out in 1896, plainly indicating great deterioration and waste.

The point, however, we desire to emphasize at this place is that humus, properly distributed in the soil, has the power to conserve the moisture in the soil to be used by a growing crop.

Summing up some of the lessons that seem to be taught by the data presented in the present bulletin and by those published in preceding bulletins, we have as

CONCLUSIONS:

1. If you would keep the soils in the best chemical and physical condition, there must be practiced such a system of of rotation that there shall be included in the rotation humus producing and humus consuming crops.

2. Two humus producing, to three humus consuming crops should, with proper cultivation, maintain the soil in its highest state of productivity.

3. Soils fertile by nature, such as the Red River Valley soil, should, under a system of agriculture, as indicated above, yield good crops, without the aid of commercial fertilizers for a thousand years. This assumes the proper use of all barn manures. And the prevention of unnecessary loss from the soil.

4. A proper system of crop rotation should result in enriching the surface soil with plant food rather than in depleting it, and especially should this be true for nitrogen and humus.

5. The first foot of soil in the Red River Valley contains enough plant food for at least 1,400 maximum crops, without drawing upon the supply of food material in the second foot or below.

6. The continuous growing of wheat, or other grains, or cultivated crop, rapidly depletes the organic matter from the second six inches of soil.

7. The growing of clover and peas in a crop rotation causes a marked increase in the organic matter and humus in the soil.

in both the first and second six inches. These plants are also nitrogen accumulators.

9. Land in crop rotation on which corn was grown in 1899, and wheat was grown in 1900, showed more than twice as much water in the first six inches, on July 14th, as as found in soil cotinuously in wheat. In the second six inches there was sixty-three per cent more water. The yield of wheat was more than seven times as great.

10. On July 14th the field on which corn had been grown the preceding year, contained 39 per cent. more nitrates than for the continuous wheat field. On July 30, the difference was even more marked being 61 per cent. more of nitrates.

11. Nitrifying bacteria in bare summer fallow were not found in the soil below two feet; probably not below eighteen inches.

12. Nitrates were found in greater abundance at a depth of seven feet than at a depth of one foot.

13. For every pound of nitrogen removed from the soil by wheat, we have lost from four to six pounds by other ways, where wheat has been grown continuously.

14. Soils on which wheat has been grown continuously since 1883, are found to be in bad condition, chemically and physically. They do not retain water well in the cultivated portion, and failed to mature a crop of wheat in the dry season of 1900.

15. The available plant food and the principal feeding ground of the wheat roots seems to be in the first eight inches of soil.

16. A soil may contain a good supply of available plant food in the first eight or ten inches, and enough water lower down, but within reach of the wheat roots, and yet fail to produce a crop literally starve, surrounded by an abundance of plant food for want of moisture in the first eight inches, to dissolve the food for the use of the plant.

17. Plowing under a green crop does not produce as beneficial results as come from plowing grass lands. Plowing under a green crop leaves the organic matter in a mass and not uniformly distributed throughout the soil.

18. After grass in a crop rotation, the soil shows a large increase in amount of organic matter but less than two-thirds as much as is found in adjoining fields of native prairie soil.

19. Soils filled with a mass of grass roots furnish, in all parts of the soil, a uniform supply of organic matter, which by gradual decay, furnishes the soil humus. This humus, reacting

upon the mineral constitutents of the soil, seems to aid in liberating and rendering available this plant food.

20. Newly broken soils do not blow. It is only after they have been cropped for a series of years, that soils begin to blow badly.

21. The great mass of fine roots intertwined about the particles of soil in the virgin prairie prevented the soil from blowing. This mass of roots acted as pins to hold the soil in place. The decay of these fine roots removes the binding agents and permits of blowing. This is quite common on lands not well cultivated and in wheat continuously.

22. Adopting a system of rotation which includes grass, will prevent the blowing by again returning to the soil the binding agents, the fine grass roots which serve as pins to hold the soil particles in place.

23. Brome grass seems to put the soil more nearly in the condition of native prairie than timothy, while clover acts as a nitrogen gatherer to replace the legumes, common on virgin soil.

24. The system of agriculture most nearly ideal for maintaining soil fertility would be one with two years in grass followed by cultivated crop then two years in grain crops, making a five years' rotation, then to be repeated.

CLIMATIC STUDIES WITH WHEAT, OATS AND CORN.

It is generally stated that while the period required to mature any crop varies with the climate, the total amount of sunshine and heat units is the same for all latitudes. Cooke* says "for example a crop of wheat requires for its growth."

	Period of Growth.	Mean Temperature of Growing Period.	Heat Units.
Near Poona (India)	115 days	74.0 degrees	8,510
At Alsace (S. France)	137 days	59.0 degrees	8,083
Near Paris (N. France)	160 days	56.0 degrees	8,960
Near Edinburgh (Scotland) ..	182 days	47.5 degrees	8,645

In discussing the results Professor Cooke says, "It will be seen from these figures that the number of thermal units required to grow and mature a crop is approximately the same (i. e. about 8,500 in the case of wheat) for all countries, and that a less number of days is consequently required to ripen a crop in countries where the sunshine is more powerful than in cooler climes."

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* The Foundations of Scientific Agriculture, page 44.

Let us see how the results compare with conditions here at Fargo. We shall give the results by months for wheat grown on the College farm, and planted on four different dates in 1899, the variety being the well known fife wheat.

Growing Period.	Period of Growth.	Mean Temperature.	Heat Units.	Hours of Sunshine.
April 25	6 days	52.2 degrees	313.26	48.5
May	31 days	60.75 degrees	1,618.70	182.0
June	30 days	63.76 degrees	1,912.80	250.0
July	31 days	68.59 degrees	2,126.47	297.0
August	5 days	66.50 degrees	332.53	40.5
	103 days		6,303.76	818.5
April 27	3 days	48.92 degrees	146.76	23.0
May	31 days	60.75 degrees	1,618.70	182.5
June	30 days	63.76 degrees	1,912.80	240.0
July	31 days	68.59 degrees	2,126.47	297.0
August 4	4 days	66.56 degrees	266.26	37.0
	99 days		6,459.47	779.5
May 5-31	26 days	55.68 degrees	1,447.68	181.5
June	30 days	63.76 degrees	1,912.80	240.0
July	31 days	68.59 degrees	2,126.29	297.0
August 1-12	12 days	66.80 degrees	802.71	64.0
	99 days		6,189.48	782.5
May 15	16 days	58.81 degrees	941.12	101.0
June	30 days	63.76 degrees	1,912.80	250.0

July	31 days	68.59 degrees	2,126.29	297.0
August 16	16 days	57.88 degrees	926.10	88.5
	93 days		5,906.31	726.5

The above gives an average of 6,214.7 heat units as the amount necessary to mature the wheat crop, an average of 98.5 days and an average of 779.5 hours of recorded sunshine. To the sunshine about fifteen per cent. should be added as unrecorded in the early morning and late evening.

The above results are for a single season, and to test the matter farther we give the record for three varieties of wheat grown in 1900.

FIFE WHEAT.

Growing Period.	Period of Growth.	Mean Temperature.	Heat Units.	Hours of Sunshine.
April 13	18 days	60.54 degrees	1,089.72	164.0
May	31 days	59.20 degrees	1,835.20	219.6
June	30 days	66.00 degrees	1,960.00	259.6
July 25	25 days	68.89 degrees	1,722.25	211.0
	104 days		6,607.17	954.2

BLUE STEM WHEAT.

April 20	10 days	60.50 degrees	605.00	89.7
May	31 days	59.20 degrees	1,835.20	319.6
June	30 days	66.00 degrees	1,960.00	259.6
July 30	30 days	68.90 degrees	2,066.70	248.0
	101 days		6,466.90	916.9

PRESTON WHEAT.

April 13	18 days	60.10 degrees	1,089.00	164.0
May	31 days	59.20 degrees	1,835.2	319.6
June	30 days	66.00 degrees	1,960.00	259.6

July 25	25 days	68.80 degrees	1,722.00	211.0
	104 days		6,606.2	954.2

For 1900 the average number of heat units required was 6,560.1 as against 6,214.7 for 1899, and an average of 103 days or four and one-half days more than for 1899, while the total hours of recorded sunshine was 908.4 or 126 hours more than in 1899., The record for the two years then gives an average of 6,387.4 heat units necessary for maturing a wheat crop at Fargo as compared with 8,500 heat units for all parts of Europe as mentioned by Cooke. The number of days averages approximately 100 as compared with 115 to 184 for Europe from date of planting to maturity. We have given the number of hours of actual sunshine for each case for the region about Fargo. Of the amount of actual sunshine for Europe during the period for the growing crop we have no available record. We do find, however, that the heat units about Fargo for maturing wheat averages 2,113 less than that given by Cooke for Europe and assumed by him to hold for any country without regard to latitude.

To account for this difference we need to consider other climatic and soil conditions, such as temperature of the soil, radiation, evaporation, rainfall, capacity of the soil to hold water, the amount of vailable food, and the times at which this food becomes available. We should, perhaps, consider also the actinic qualities of the sun's rays for different localities and conditions, particularly as affected by the moisture in the atmosphere. The soil temperature for the two years may help throw some light on the difference for the years studied at Fargo.

SOIL TEMPERATURE 1899.

	Soil 1 Inch.	Soil 6 Inches.
April 25 to 30	57.0 degrees	42.2 degrees
May	55.9 degrees	45.6 degrees
June	66.5 degrees	53.6 degrees
July	73.9 degrees	65.1 degrees
August 1 to 12	74.8 degrees	64.6 degrees

SOIL TEMPERATURE FOR 1900.

	Soil 1 Inch.	Soil 6 Inches.
April 15 to 30	59.1 degrees	45.5 degrees
May	[illegible].2 degrees	52.1 degrees
June	73.8 degrees	62.2 degrees
July	71.5 degrees	64.0 degrees

The averages above are for 12 o'clock noon readings in both cases. It is noticeable that the soil temperatures for the depth of six inches in 1900 particularly for May and June averaged quite a little above those for 1899. It is evident therefore that soil temperature alone could not have made the difference for the two years. Studies along the line of soil moisture, available plant food and moisture in the air were undertaken the present season. When these studies are completed, it is believed some light will be thrown on this question.

HEAT UNITS FOR OATS.

Below we give the data for 1899 regarding the heat units calculated in a similar manner for oats.

Growing Period.	Period of Growth.	Mean Temperature.	Heat Units.
May 8 to 31	24 days	50.86 degrees	1,220.6
June	30 days	63.76 degrees	1,912.8
July	31 days	68.59 degrees	2,126.3
August 4	4 days	66.56 degrees	266.2
Total	89 days		5,525.9

OATS FOR 1900.

Growing Period.	Period of Growth.	Mean Temperature.	Heat Units.
April 20 to 30	10 days	60.5 degrees	605.4
May	31 days	59.2 degrees	605.4

June	30 days	66.0 degrees	1,960.0
July 1 to 21	21 days	68.9 degrees	1,446.7
Total	92 days	68.9 degrees	5,847.3

As with the wheat a greater number of heat units were required for developing the oat crop of 1900 than for 1899.

HEAT UNITS FOR A CORN CROP.

For the year 1899 we present in a similar manner the data for a corn crop:

Growing Period.	Period of Growth.	Mean Temperature.	Heat Units.
May 22 to 31	9 days	58.20 degrees	52.38
June	30 days	36.76 degrees	1,912.8
July	31 days	68.59 degrees	2,126.3
August	31 days	67.70 degrees	2,098.9
September 1 to 12	12 days	64.20 degrees	770.5
Total	113 days		7,432.3

In like manner presenting the data for the corn crop of 1900 we get for heat units the following results:

Growing Period.	Period of Growth.	Mean Temperature.	Heat Units.
May 19 to 31	12 days	63.7 degrees	764.4
June	30 days	66.0 degrees	1,980.0
July	31 days	68.9 degrees	2,135.9
August ......,...	31 days	72.8 degrees	2,256.8
September 1 to 10	10 days	67.5 degrees	675.0
Total	114 days		7,812.1

With the corn as with the other cereals, a greater number of heat units were required for maturing a crop in 1900 than in the previous year.

The only American data available to the writer, bearing on this subject, is the results of some observations made by Dr. Sturtevant,* for the years 1883, 4 and 5. But his results are only given for the period between planting and blooming of corn, and do not cover the period from bloom to maturity. For Waushakum corn for the year mentioned he gives the heat units as follows:

		Heat Units.
1883		3,727 degrees
1884		3,659 degrees
1885		4,103 degrees

The number of days from planting to blooming was from 56 to 60.

For Chester County Mammoth Sweet Corn, according to the same authority, the number of days from planting to bloom and the heat units are quite different as shown below:

	Number of Days.	Heat Units.
1883	74	5,117 degrees
1884	80	5,268 degrees
1885	70	4,850 degrees

Here different varieties of corn, and different years, for the same variety give us different results. Further studies in other directions are necessary before any conclusions of value can be drawn. It would seem, however, that the conclusions of Cooke are not applicable as general principles for plant growth as might be inferred from his statements.

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* Fourth Annual Report, New York Agricultural Experiment Station, (Geenva) for 1885.

BROME GRASS AND TIMOTHY COMPARED.*

BY E. F. LADD AND ADELE SHEPPERD.

In the early spring of 1900 an experiment was planned to determine the amount of pasturage that two meadows, the one laid down in timothy and the other in brome grass, would furnish during the grazing season. Another experiment was planned for the purpose of determining the relative value of brome and timothy for hay, considering the yield and chemical composition of the two hays.

BROME AND TIMOTHY AS PASTURE GRASS.

In this experiment it was planned to cut the grass from both lots on the same date and at a time when either had reached a sufficient height to furnish good grazing or as a rule when one of the grasses had reached a height of about four to five inches.

The season was so unfavorable for this investigation that the results were not wholly satisfactory. Many interesting points were, however, brought out in the study and perhaps fully as valuable data secured as would have been possible to secure in a more favorable season.

Much was learned regarding the drought—resisting qualities of the two grasses, and what we may expect from brome grass in unfavorable seasons.

The land selected for the experiment was a meadow that had been down in grass for several years and the soil had become very firm and filled with a mass of roots penetrating, in case of the brome grass, to a great depth.

The total yields per acre for the green grass for the several cuttings were as follows:

Date Cut.	Pounds Per Acre.	
	Brome Grass.	Timothy.
May 9	974.4	678.4
June 5	848.0	480.0
July 19	1,296.0	704.0

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* The field experiments and all analytical work and the compilation of results are the work of Adele Shepperd, but the responsibility for the presentation of the data belongs to E. F. Ladd.

August 13	915.2	755.2
September 17	1,504.0	2,064.0
Total	5,537.6	4,681.6

After the late summer rains the timothy came forward very rapidly and for September yielded 560 pounds per acre more pasture grass than did the brome grass, but the total yield for the entire season was 856 pounds more feed per acre for the brome grass.

The composition of the fresh grass is shown in the following table:

ANALYSIS OF BROME GRASS. (PASTURE.)

	May 8.	June 5.	July 18.	Aug. 13.	Sept. 17.
Water	69.78	66.35	69.40	74.31	72.28
Ash	2.99	3.45	3.61	2.52	2.33
Fat	2.55	2.20	2.30	2.01	1.96
Crude fiber	5.65	5.71	7.15	5.59	5.84
Protein	5.22	4.93	4.49	5.72	4.59
Nitrogen—free extract	13.81	17.36	13.05	9.85	13.00

The variation in water content is as might be expected, when the rainfall and climatic conditions for the season are considered. Similar relations are shown for the timothy samples taken at the same dates. The analytical results are given in the following table:

ANALYSIS OF TIMOTHY GRASS. (PASTURE.)

	May 9.	June 5.	July 19.	Aug. 13.	Sept. 17.
Water	63.72	64.46	65.41	76.05	71.82
Ash	3.10	2.82	3.04	2.41	3.18
Fat	2.18	2.29	2.20	1.67	1.95
Crude fiber	5.77	5.41	7.36	5.23	5.71
Protein	6.16	5.93	5.42	5.18	4.21
Nitrogen—free extract	19.07	19.09	16.57	9.46	13.12

With variable amounts of water content it is difficult to judge of the relative values of the two grasses. In the following we give the yield per acre of dry matter for each cutting and for the season.

Date Cut.	Pounds Per Acre.	
	Brome Grass.	Timothy.
May 9	294.5	246.1
June 5	285.4	170.6
July 19	396.6	243.6
August 13	235.0	180.9
September 17	416.8	581.6
Total	1,628.3	1,422.8

The yield peracre of dry matter for the summer was 216 pounds more for the brome grass pasture than for the timothy. Another interesting feature was that while the brome grass about the lot under examination made a good growth yielding a fair cutting of hay, the grass on the timothy sod never attained above four inches in height by the usual hay harvest season; consequently there was nothing that could be cut with a mower. The brome was therefore cut for hay, yielding from three-fourths to one and a half tons per acre.

Considering the composition of this dry matter, we have as follows for brome grass:

	May 9.	June 5.	July 19.	Aug. 13.	Sept. 17.	Average.
Ash	9.59	10.27	11.80	9.84	8.41	9.98
Fat	7.80	6.54	7.52	7.86	7.08	7.36
Crude fiber	18.71	16.98	23.06	21.77	21.10	20.32
Protein	17.30	14.67	14.68	22.27	16.56	17.10
Nitrogen—free extract	46.60	51.54	42.94	38.26	46.85	45.24

The analysis of the timothy for same dates of cuttings is given below.

	May 9.	June 5.	July 19.	Aug. 13.	Sept. 17.	Average.
Ash	8.55	7.94	8.81	10.08	11.30	9.33
Fat	6.02	6.45	6.37	7.01	6.96	6.56
Crude fiber	15.91	15.24	21.30	21.86	20.29	18.92
Protein	16.91	16.71	15.68	21.65	14.96	17.18
Nitrogen—free extract	52.53	53.66	47.84	39.40	46.49	48.01

The results show very little difference for the two years as far as their chemical composition is concerned.

The total yield for the various constituents of the brome grass at the several cuttings was as follows in pounds per acre.

	May 9.	June 5.	July 19.	Aug. 13.	Sept. 17.	Total.
Ash	28.23	29.30	46.83	23.13	35.10	162.06
Fat	22.96	18.66	29.82	18.47	25.91	119.4
Crude fiber ..	55.08	48.45	91.44	51.18	87.96	334.1
Protein	50.93	41.86	58.21	52.35	60.03	272.4
Nirtogen—free extract	137.20	147.06	170.28	89.94	195.31	749.8
Total	......	......	......	......	......	1,638.[illegible]

The amounts for timothy was as shown in the following:

	May 9.	June 5.	July 19.	Aug. 13.	Sept. 17.	Total.
Ash	21.04	13.54	21.45	18.23	65.72	139.9
Fat	14.81	11.00	15.56	12.67	40.48	94.5
Crude fiber..	39.15	25.99	51.86	30.53	118.01	274.5
Protein	41.81	28.50	38.18	39.15	87.01	234.6
Nitrogen—free extract	129.28	91.53	116.49	71.25	270.39	678.9
Total	......	......	......	......	......	1,422.4

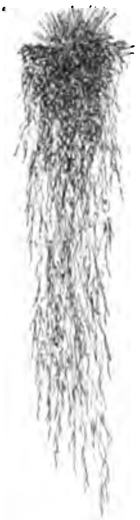
If we bring together the totals for the season's yields we can see at a glance the relative value of the two hays for pasture purposes, so far as yield of food material is concerned.

	Pounds Per Acre For Year.		
	Brome.	Timothy.	Brome Grass. Gain.
Ash	162.6	139.9	22.7
Fat	119.4	94.5	24.9
Crude fiber	334.1	274.5	59.6
Protein	272.4	234.6	37.8
Nitrogen—free extract	749.8	678.9	70.9
Total	1,638.3	1,422.4	215.9

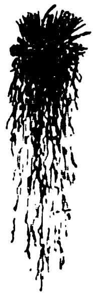
The results show a decided gain in each constituent for the brome over the timothy and a total net gain of 216 pounds of dry matter per acre. This gain on a large pasture for a season like that of 1900 would make a very decided difference in favor of brome grass for permanent pasture. Another noticeable fact was the observation that cattle grazing in a pasture in part laid down to timothy and in part to brome grass manifested a decided preference for the brome grass. In 1899 this was so marked that while the part in brome grass was kept grazed close, the portion in timothy came up to full maturity and remained untouched by the animals. In 1900 until the late fall rains came on, breaking the long drought, the brome grass continued to furnish good pasturage, while there was very little grazing to be had from the timothy sod.

AUSTRIAN BROME HAY.

(Bromus inermis.)



Brome grass roots



Timothy roots

This experiment was intended to show the difference in value between brome and timothy as a hay crop, also the proper stage of maturity at which to cut brome grass in order to produce the best hay. The season of 1900 was so dry that timothy on the College farm failed to produce a crop for hay. On the other hand brome grass yielded from three-fourths to one and a half tons of hay per acre. If we examine the root system of the two grasses we find a reason for this difference in a year like the past season. Professor TenEyck has shown that while brome grass extends its roots down for a depth of five to six feet, timothy roots did not go deeper than three and one-half feet. The difference in root bulk is also shown by the accompanying cuts. The deep rooting and feeding system of brome grass enable it to secure the necessary supply of moisture and food material to produce a fair yield in spite of the severe drought prevailing during the first half of the year. This seems to show very clearly the value of brome grass for the dryer portions of our state.

The grass was cut at three stages of growth when in blossom or at the time the seed were forming, when in the milk stage and when fully mature. The yield for these dates was as follows:

	Pounds Per Acre.	
	Fresh Substance.	Dry Substance.
June 21	5,637	2,290
June 25	6,456	2,462
July 9	7,632	2,802

When brome grass is well matured we find considerable more of total dry matter than when cut earlier.

The following table gives the composition of the hay for the several dates, on which samples were taken.

	Fresh Substance.		
	June 21.	June 21.	July 9.
Water	59.38	61.86	63.29
Ash	2.72	2.48	2.37
Fat	2.35	2.28	2.51
Crude fiber	10.97	10.84	10.60
Protein N.x6.25	5.20	5.49	4.98
Nitrogen—free extract	19.38	17.05	16.25

The increase in per cent. of water as the grass approaches maturity is an anomaly due to the peculiar climatic conditions of the season and contrary to what would be ordinarily found in more favorable seasons. For better comparison we calculate the results to water free content.

	Dry Substance.			
	June 21.	June 25.	June 19.	Average.
Ash	6.56	6.52	6.46	6.56
Fat	5.79	6.00	6.86	6.22
Crude fiber	27.02	28.43	28.88	28.11
Protein N.x6.25	12.81	14.40	13.59	13.50
Nitrogen—free extract	47.67	44.65	44.21	45.51

The above shows that the per cent. of fiber increased very little from June 21st to July 9th and in fact the principal changes seem to have been in fat and proteids and not the increase of starch, as might have been expected, judging from other similar lines of research. Whether a more favorable season would give results differing from these, needs to be determined before drawing any definite conclusions.

The yield per acre for the several constituents are given in the following table:

	Pounds Per Acre.		
	June 21.	June 25.	July 9.
Ash	153.6	160.5	180.9
Fat	132.6	147.7	192.2
Crude fiber	618.6	700.0	809.1
Protein	293.3	354.6	380.7
Nitrogen—free extract	1,091.5	1,098.4	1,238.6

The valuable food constituents in the brome grass continued to increase up to the stage of full maturity. The above results are not wholly in accord with those found by the writer in experiments with timothy,* at different stages of maturity. It is quite probable that the climatic conditions for 1900 may have produced departures from the normal conditions of the grass. This can only be determined by further study the present season.

Our results show nothing as to the relative composition or values for timothy and brome grass, since no timothy was grown for that year. The average for all analyses for timothy as published by the Department of Agriculture in their compilation for 1892 gives for dry substance as shown below in comparison with our analysis for brome grass and that of native prairie grass hay.

COMPOSITION OF DRY SUBSTANCES.

	Average for Timothy.	Prairie Grass Hay.	Brome Hay.
Ash	5.10	7.87	6.56
Fat	2.90	4.56	6.22
Crude fiber	33.50	27.98	28.11
Protein	6.80	7.51	13.60
Nitrogen-free extract	51.70	52.08	45.51

These results indicate very plainly that brome grass as grown on the College farm contains twice as much of nitrogenous matter —protein—as is found in the average timothy hay for the whole

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* New York State Agricultural Experiment Station report for 1887, page 431.

United States. Brome hay contains 6 per cent. more protein than is found in the native prairie grass hay as shown by our analysis above. In fact the results above indicate brome hay to contain nearly as much protein as the average for red clover hay. Judging from the chemical analysis this hay has a feed value superior to any other hay produced in the state, while the experiments already presented show it to be a surer hay or pasture crop than timothy, especially for dry seasons or in regions of low rainfall.

Analyses for brome hay have been made at other Stations, a few of which results we give below for comparison.

	Brome Hay. Dry Substance.				
	Ash.	Fat.	Crude fiber.	Protein.	Nitrogen free ext.
North Dakota	6.56	6.22	28.11	13.60	45.51
Canada	3.78	2.41	33.90	11.88	48.03
South Dakota	8.08	2.06	41.27	10.79	37.80
Iowa	10.20	1.60	34.51	11.92	41.77
Connecticut	7.60	3.43	28.84	8.02	52.06
Connecticut	9.00	3.38	27.83	8.09	51.70
Connecticut	7.76	3.51	28.52	9.39	50.82
Connecticut	7.33	4.25	30.33	13.38	44.71

The results for Connecticut are particularly interesting as showing the influence of fertilizers on the composition. The last one was grown on land heavily fertilized with nitrates and phosphates and the per cent. of protein is nearly as high as found for brome hay on the College farm and indicates the influence of fertile soils on the character of food products produced.

BROME GRASS AS A HUMUS FORMER.

The brome grass, as shown in the cut, furnishes a much greater amount of roots than the timothy. It fills the ground with such a mass of fibrous roots that when land is plowed the difference in appearance is so marked that it is noticeable for a long distance. It would seem that soil filled with brome grass roots would not, when plowed, blow more than did the original prairie soil breaking during the first few years, or until these roots were rotted in the soil. A field, one part in timothy and the remainder in brome grass, was plowed early in the summer of 1900 and replowed in the fall. In February of the present year the land was sampled and examined to determine what real difference could be found. The results of this experiment follow.

	Per Cent.	
	Brome Sod.	Timothy Sod.
Organic matter	20.56	17.10
Humates (Extractive matter)	17.11	14.95
Humus	7.04	6.10
Nitrogen	.52	.50

The results show that brome grass sod eight months after plowing contains 3.46 per cent. more organic matter and one per cent. more humus than the timothy sod. The brome grass roots are more porous and bulky than those of timothy and give a more marked appearance to the soil than is indicated by the weight of organic matter. On decaying, soils containing the brome roots do not agglutinate so firmly in little masses as does the soil where timothy was grown. This shows that the physical condition of the two soils is quite different. The water holding capacity of the soils is for the

	Per cent.
Brome sod	73.40
Timothy sod	68.20

Showing 5.20 per cent. in favor of the brome grass soil over that of timothy. It is our purpose to make further experiments and analyses during the present year.

CONCLUSIONS.

1. Brome grass produced a fair amout of pasturage in the dry year of 1900 while timothy made very little growth.
2. Animals prefer brome pasture to timothy as shown in their grazing for 1899, when there was an abundance of both grasses, and in 1900 we have like results.
3. There was but little difference in chemical composition between pasture grass from brome and from timothy. The total yield per acre was much in favor of the brome grass.

4. Brome grass made a fair crop of hay in 1900, while timothy failed.
5. Brome hay contains about twice as much protein as timothy.
6. Brome hay does not contain more fiber than the average for timothy grown in all part of the United States.
7. Brome grass sends its roots down deeper into the soil than timothy and furnishes a great mass of roots in the first foot of soil and hence the soil may be expected to blow less when plowed.
8. Soils on which brome grass has been grown contain more organic matter and humus than those on which timothy has been grown.
9. Brome grass is a better humus former than timothy and leaves the soil in better chemical and physical condition than does the timothy.

Bulletin No. 46, a catalogue of the seed bearing plants of North Dakota, is not for general distribution. It is a technical bulletin and will be supplied to those who are interested in the state flora.

ERRATA.

On pages 688-9 under Colonies of Bacteria the star indicates lost, and in the column Nitrates and Nitrites the star indicates trace.

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 48.

WHEAT FARMING EXPERIMENTS AND SOIL MOISTURE STUDIES.

1. THE WHEAT CROP OF 1900 GROWN UNDER DIFFERENT METHODS OF FARMING.
2. A STUDY OF THE CONSERVATION OF SOIL MOISTURE:
   - (a) By Cultivation.
   - (b) By Crop Rotation.
   - (c) By Different Methods of Summer Fallowing.
   - (d) By Manuring.
3. A STUDY OF THE EFFECT OF THE WINTER SEASON UPON THE MOISTURE CONTENT OF THE SOIL.
4. WEATHER AND CROP RECORDS FOR 1898, 1899 AND 1900.

Any farmer, teacher or student in the state can have this Bulletin mailed to his address, free of charge, upon application.

Fargo, North Dakota, U. S. A.
June, 1901.

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WHEAT FARMING EXPERIMENTS AND SOIL MOISTURE STUDIES.

BY J. H. SHEPPERD AND A. M. TEN EYCK.

SUMMARY.

1. The year 1900 was one of the driest early and the wettest late seasons recorded in the history of North Dakota.

2. The soil contained more moisture November 15th, 1900, than had ever before been recorded on that date at this Station.

3. If the moisture could all be conserved for the use of plants, only about one-half of North Dakota's rainfall would be needed to grow a crop of wheat.

4. Plowing six inches deep gave 50 per cent. greater yield in 1900 than plowing three inches deep upon land which had been in wheat for five years.

5. Good cultivation on spring plowed land gave nearly double the yield obtained from ordinary cultivation upon continuously wheat cropped soil.

6. The best continuous wheat plot yielded about half as much as those which had been rotated with corn or potatoes.

7. Good cultivation alone is not sufficient to produce good crops—a rotation is a necessity for both wheat and flax.

8. Good cultivation increased the yield of flax 70 per cent. upon wheat continuously land, while land which had grown corn in 1899 yielded about 140 per cent. better than the ordinary wheat land.

9. Wheat left 21 per cent. of moisture in the soil upon the Station grounds as unavailable moisture, and the soil of all the plots was uniformly dry at harvest time.

10. Corn land went into the winter season, November 15th, 1900, with two inches more water in the soil than wheat or flax land, and one inch more than potato and millet ground despite the heavy summer and autumn rains.

11. Bare, cultivated land contained the largest amount of moisture and timothy ground the least at the close of the season.

12. Little change occurred in the moisture content of the soil during the winter of 1900-01.

13. On July 24, 1900, (before the rain fell) corn ground contained 5.7 inches more water than wheat ground.

14. Barren summer fallow (plowed once) with no cultivation is little better than continuous wheat growing for conserving soil moisture.

15. The manured ground produced nine per cent. greater

crops, but contained five per cent. less moisture in the soil at harvest time than did the unmanured ground.

16. In the spring of 1901 the manured land contained more moisture in the surface soil than the unmanured land.

17. The water table falls during the winter season, but there is little or no loss of soil moisture and there is an actual gain of moisture in the surface soil, which is not due to rain or snow.

18. The Campbell method has yielded small crops of wheat and has given no appreciable saving of soil moisture.

19. Poorer yields were obtained upon shallow than upon deep plowing.

20. Disk plowed land has not yielded so well as shallow plowed. The John Deere secretary plow was used in these trials.

21. Subsoiling has increased the yield, but required a little more water to produce the crop.

22. Sub-surface packing and harrowing after plowing have given a slight increase in yield, and have conserved the soil moisture.

23. Rolling and harrowing have given increased yields in wheat, especially upon spring plowing, but the soil has been left drier than the ordinary plowing at harvest time.

24. Harrowing wheat conserved the soil moisture, and proved beneficial.

25. As an average for all trials for two years, it required about one inch of water to produce two bushels of wheat.

26. Moisture stored in the soil seems to do the crop more good than that which falls as rain, during the average season.

THE WHEAT CROP OF 1900 GROWN UNDER DIFFERENT METHODS OF FARMING.

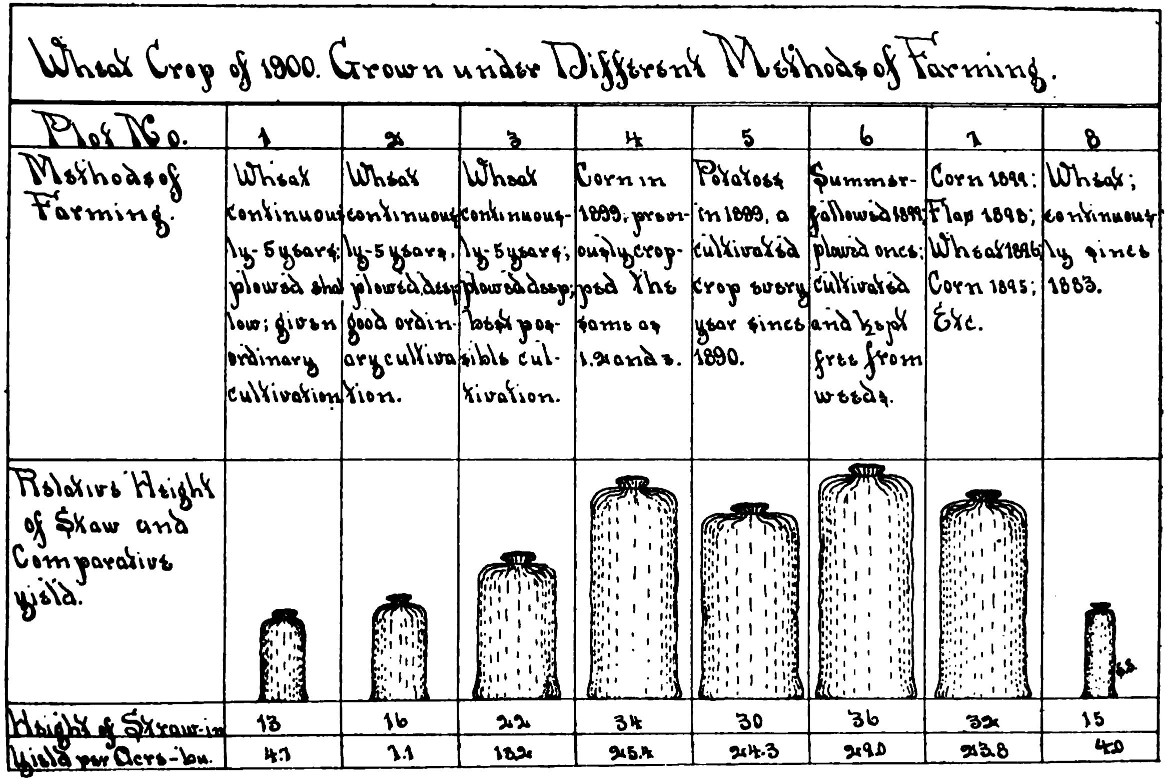
The year 1900 is remarkable in having been one of the driest and also one of the wettest seasons recorded in the history of North Dakota. The mean annual rainfall for the past nine years at the Station has been 19.78 inches, (the average for the state, 17.23 inches). In 1900 the total precipitation at this Station was 25.54 inches, or 5.76 inches above the average for nine years. The heaviest annual rainfall recorded at this Station, except that for 1900, is 22.3 inches and fell during the year of 1897. (See the Eleventh Annual Report, page 17.)

The fall and winter of 1899 were exceptionally dry and during the months of April, May and June, 1900, only 4.7 inches of rain fell, or less than half of the normal amount for those months. The result was an almost total failure of the grain crops.

The precipitation during the month of July, 1900, was 3.91 inches, a little above the normal amount. Nearly twelve inches of rain fell during the months of August and September and more than eight inches in the month of August alone. The rains came too late to save the crop, but the soil was filled with water and the ground went into winter condition containing more moisture November 15th than has ever before been recorded on that date by this Station. It seems reasonable to assume that if this moisture is properly conserved, the crop of 1901 will not suffer from drouth.

The most uncertain factor in the production of crops is the moisture supply. The annual rainfall is sufficient to produce a crop, but its irregular distribution, unless it is carefully preserved in the soil by proper methods of cultivation and crop rotation, often leads to crop failure. Careful estimates show that if the moisture could all be conserved for the use of the crop, only about one-half of North Dakota's rainfall would be needed to grow wheat. The crop of 1900 grown under different methods of farming at this Station has demonstrated that it is possible to so rotate crops and cultivate the land as to conserve sufficient moisture in the soil to produce good crops of wheat even in very dry seasons.

The Station has conducted a series of rotation and cultivation experiments with wheat for several years. Valuable results have been obtained and in 1900 the difference in the crops on several of the plots was so marked as to present an object lesson to all who saw the fields. In the following descriptive diagram, an attempt has been made to present, by contrast, the results of the 1900 crop:



Wheat Crop of 1900. Grown under Different Methods of Farming.

Plot No.	1	2	3	4	5	6	7	8
Methods of Farming.	Wheat continuously 5 years; plowed shallow; given ordinary cultivation.	Wheat continuously 5 years, plowed deep; good ordinary cultivation.	Wheat continuously 5 years; plowed deep; best possible cultivation.	Corn in 1899; previously cropped the same as 1, 2 and 3.	Potatoes in 1899, a cultivated crop every year since 1890.	Summer-fallowed 1899; plowed once; cultivated and kept free from weeds.	Corn 1899; Flax 1898; Wheat 1896; Corn 1895; Etc.	Wheat; continuously since 1883.
Relative Height of Straw and Comparative yield.								
Height of Straw-in	13	16	22	34	30	36	32	15
Yield per Acre-bu.	4.7	7.1	18.2	25.4	24.3	29.0	23.8	4.0

DIAGRAM I

The size of the sacks represents the relative yield per acre from the several plots. The height of the sacks shows the relative length of the straw. Each vertical column represents a separate plot. Above the representation of the sack in each column the method of farming is described; below is given the actual yield in bushels per acre and the length of straw in inches.

Plot 8 has been farmed to wheat continuously for the past twenty years. On this plot the wheat made a thin, spindling growth of straw with short heads and yielded four bushels of grain per acre.

Plot 1 has been in wheat continuously for five years. It has been fall plowed shallow (three to four inches deep) each year and given ordinary cultivation, i. e., only what was considered necessary to permit sowing and covering the seed properly. The wheat made a poor growth and was thin and weedy, the yield being only 4.7 bushels per acre.

Plot 2 has been plowed six to seven inches deep each year, while otherwise the cultivation and cropping has been similar to that already described for plot 1. The yield was 7.1 bushels per acre, or nearly two and one-half bushels more than was obtained from the shallow plowing

Plot 3 is in the same series as plots 1 and 2, but it has been given a little better cultivation and was spring plowed six to seven inches deep in 1900. The yield was 13.2 bushels per acre, almost double that obtained on the fall plowing. This large increase in crop was mainly due to the spring plowing as is shown by the fact that fall plowed plots which received extra cultivation did not have their yields materially increased. This plot, however, presents the best yield which was obtained from land which had grown wheat continuously for several years. Compare this yield with that of the crop from land which has been given a proper rotation of crops.

Plot 4 is similar in every respect to plots 1, 2 and 3 and until 1899 received the same system of cropping. Corn was grown on this land in 1899, the ground was fall plowed and given ordinary cultivation in the spring. The wheat was sown in the ordinary way. The grain on this plot stooled well, made a rank growth, stood thirty-four inches high and yielded 25.4 bushels per acre, almost twice the yield received from the best wheat continuously plot and three and one-half times the yield of plot 2, which was plowed and cultivated in exactly the same manenr as plot 4. The difference in crop evidently was due entirely to the rotation wtih corn.

Plot 5 is the same kind of land as the plots which have already been described but has been subjected to rotation for a longer period than has plot 4. The yield of wheat from this plot was 24.3 bushels per acre, and the straw was a little shorter than that grown on plots 4 and 6.

Plot 6 has been previously rotated in the same manner as plot 5, but in 1899 the land was allowed to lie fallow and was kept cultivated and free from weeds. This plot gave the largest yield received last season, viz., 29 bushels per acre, and also produced the longest straw. In previous rotation experiments larger yields have been obtained, on the average, after cultivated crops than after summer fallow.

On plot 7 wheat was grown after corn the same as on plot 4, but the rotation has been kept up longer, (since 1892), and flax is included as one of the crops in the rotation. The yield was 23.8 bushels per acre.

The difference between poor and good plowing, as shown in Diagram I, was two and one-half bushels per acre in favor of the better work. In previous experiments, land which was harrowed after plowing in the fall, rolled and harrowed after sowing and harrowed once when the wheat was up six inches high gave an increase of four and one-half bushels of wheat per acre over land which received only the ordinary cultivation necessary to put in the crop. It is evident, however, from the above study that good cultivation alone is not sufficient. Proper rotation of crops is necessary in order that land may continue to produce profitable crops of wheat.

The above statements are true also in regard to flax. By good plowing and extra cultivation the yield of flax in 1900 was increased, on spring plowed land which had grown wheat continuously, from five and one-half to nine and one-half bushels per acre, but a crop of flax which received no extra cultivation on land which grew corn in 1899 gave an estimated yield of sixteen bushels per acre, six and one-half bushels more than was obtained by the best cultivation on the wheat continuously land. In a single previous experiment in 1897, flax on summer fallow yielded 6.1 bushels more per acre than flax after wheat, the crops receiving similar cultivation.

In Fig. I are shown samples of the flax crop of 1900 which were grown by different methods of farming.

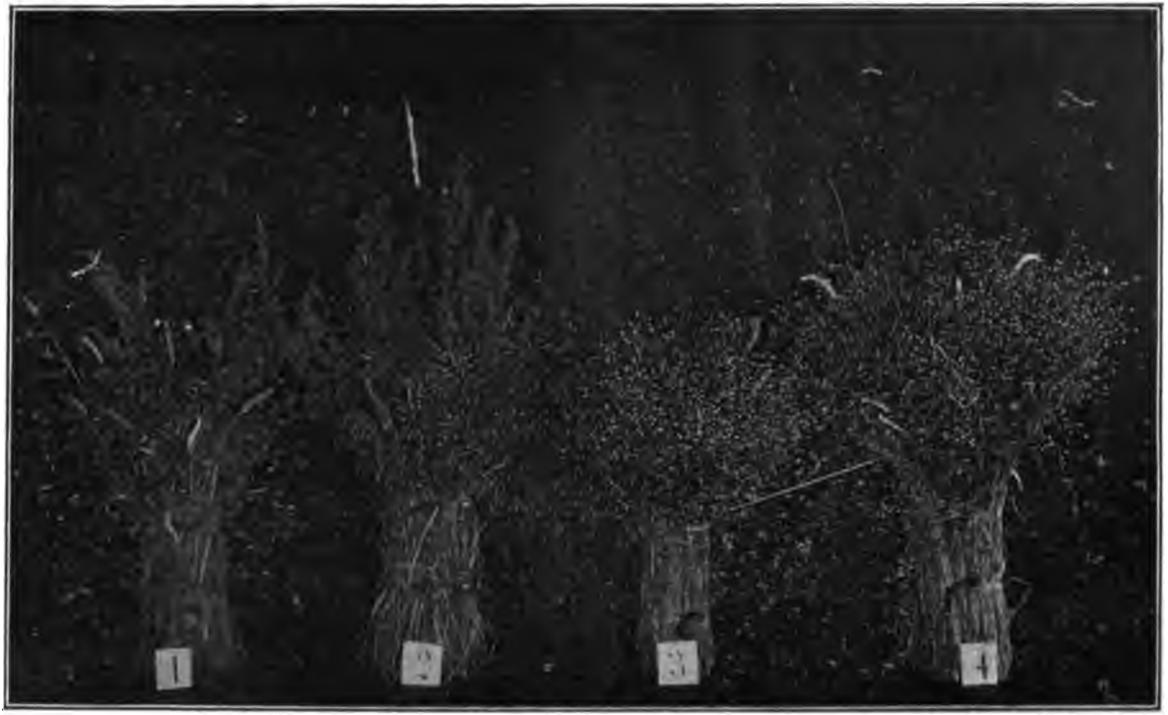


FIG. 1—SAMPLES OF THE FLAX CROP OF 1900

DESRIPTION OF SAMPLES IN FIG. 1

No.1—Flax after four crops of wheat on land which has been farmed for twenty years. The ground was fall plowed and given ordinary cultivation. The flax was sown May 16th. Yield per acre, 7.4 bushels.

No. 2—Flax after four crops of wheat on land which has been farmed for twenty years. The ground was spring plowed and given ordinary cultivation. The flax was sown May 16th. Yield per acre, 6.8 bushels.

No. 3—Flax after wheat from land which has received the following rotation of crops: 1893, summer fallow; 1894, wheat; 1895, wheat; 1896, flax; 1897, summer fallow; 1898, wheat; 1899, wheat; 1900, flax; previously in wheat since 1883. This ground was fall plowed in 1899 and well cultivated in the spring of 1900 and kept free from weeds until the flax was sown, May 15th. Yield per acre, 10.4 bushels.

No. 4—Flax after corn from land which had previously been in wheat the same as stated for Nos. 1 and 2. The ground was fall plowed in 1899 and well cultivated in the spring of 1900 and kept free from weeds until the crop was sown, May 24th. Estimated yield per acre, 16 bushels.

CONSERVING SOIL MOISTURE BY CULTIVATION.

The dry season in which the crop was produced by different methods of farming leads to the conclusions that the large difference in the yields from the several plots must be in some way directly related to the amount of moisture which had been stored in the soil previous to the sowing of the wheat. Samples of soil were taken to the depth of three feet from plots 1, 2 and 3 on April 20th. a few days after the wheat was planted. The results are given in Table I.

TABLE I

Showing the Percentages of Moisture Found in the Soil at Seeding Time April 20, 1900.

Plot No.	METHOD OF CULTIVATION.	MOISTURE PERCENTAGE				CROP 1900
		First foot	Second foot	Third foot	Average	bu.
1	Fall plowed shallow, ordinary cultivation....	25.75	20 70	22.13	22.63	4.7
2	Fall plowed deep, good cultivation.........	24.92	20.66	23.35	22 87	7 1
3	Spring plowed deep, good cultivation.........	31.13	21.76	2[illegible].06	23.16	13.2

The results show that the average moisture content to the depth of three feet varied in accordance with the yield of wheat obtained, but not in the same proportion. The larger amount of water in the surface soil of the spring plowed land gave a decided advantage to the crop on that ground in early spring, and effected it during the entire season.

Plots, 1, 2 and 3 are included in a series of cultivation experiments with wheat which have been carried on for four consecutive seasons.

Reports upon these experiments have been published in Bulletins Nos. 29 and 38 of this Station. An extensive study of the moisture conditions of the soil has been made in connection with these trials. The following tables give the summarized results of three years' work:

TABLE II.

Summarized Results of the Soil Moisture Study made in Connection with Cultivation Experiments with Wheat.

FALL PLOWED LAND.

GENERAL METHOD OF CULTURE.	CROP OF 1898.						CROP OF 1899.						Averages for 1898 and 1899.	
	No. of plots in the trial.	Average Moisture.				Yield of wheat, per acre.	No. of plots in the trial.	Average Moisture.				Yield of wheat, per acre	†Water exhausted from 3 feet of soil plus rainfall.	Yield of wheat, per acre.
		At sowing time		At harvest time, average for 3 feet	† Water exhausted from 3 feet of soil plus rainfall.			At sowing time		At harvest time, average for 3 feet	† Water exhausted from 3 feet of soil plus rainfall.			
		First foot	Average for 3 feet					First foot	Average for 3 feet					
		per ct.	per ct.	per ct.	in.	bu.		per ct.	per ct.	per ct.	in.	bu.	in.	bu.
Cultivated in rows	10	37.13	33.01	23 36	11.65	21.47	10	35.18	30.51	22.96	12.20	19.97	11.92	20.72
Ordinary plowing	2	38 93	33.84	24 57	11.50	27.90	2	36 67	30.60	23.22	12.10	20.57	11.80	24.23
Shallow plowing	2	39.32	34 47	25.06	11.55	27 00	2	38.45	31.13	23.39	12.25	19.50	11.90	23 25
Sub-surface packed	2	39.48	34.47	24.43	11.81	28 28	2	35.38	29.14	22.09	11 97	20.07	11.89	24.17
Harrowed after plowing	2	36 46	33.53	23 50	11.71	25.98	2	36.35	28.88	23 64	11.24	21 15	11.47	25.06
Subsoiled 4 and 6 inches	4	36.89	32 89	23.27	11 64	27.72	2	37.11	31.35	21.99	12.89	19.24	12.26	23.48
Subsoiled 8 inches	4	39.02	32.45	23.50	11.37	29 26	4	37.06	30.43	22.14	12.51	21.04	11.94	25.15
Disc plowed	4	37.63	35.86	25.70	11.86	26 79	4	40.61	33 22	24 57	12 69	17 22	12 27	22.00
Rolled after sowing	1	36 79	32.16	24.15	10.98	27.70	1	36.34	31.89	23.59	12.47	19 80	11.72	23.75
Harrowed after sowing	2	35 87	34.20	23.76	11.97	28.64	1	36.59	30.62	24 65	11.53	20 00	11.75	24 32
Rolled and harrowed after sowing	1	34.26	30.55	23.55	10.59	28.47	1	38.15	34.26	21 99	14.07	21.47	12.33	24.97
Harrowed, wheat 6 inches high	2	......	......	- ...	......	......	2	35.70	29.36	25.71	10 60	21.85	... ...	......
* Averages	2½	37.46	33.44	24.15	11 50	28.05	2	37.13	30.99	23.36	12.21	20.17	11.83	24.04

*) "Cultivated in rows" not included in the averages.

†) Rainfall in 1898, 7.75 inches; in 1899, 9.12 inches.

TABLE III.

Summarized Results of the Soil Moisture Study made in Connection with the Cultivation Experiments with Wheat.

SPRING PLOWED LAND.

GENERAL METHOD OF CULTURE.	CROP OF 1898.						CROP OF 1899.						Average for 1898 and 1899.	
	No. of plots in the trial.	Average Moisture.				Yield of wheat, per acre	No. of plots in the trial.	Average Moisture.				Yield of wheat per acre	+ Water exhausted from 3 feet of soil plus rainfall	Yield of wheat per acre
		At sowing time		At harvest time, average for 3 feet.	+ Water exhausted from 3 feet of soil plus rainfall			At sowing time		At harvest time, average for 3 feet.	+ Water exhausted from 3 feet of soil plus rainfall.			
		First foot,	Average for 3 feet					First foot	Average for 3 feet					
		per ct.	per ct.	per ct	in.	bu.		per ct.	per ct.	per ct.	in.	bu.	in.	bu.
Cultivated in rows	10	34.42	31.84	24 19	10 84	20.75	10	36.01	31 86	22.74	13.28	13.16	12.06	16.95
Ordinary plowing	2	34.92	31 46	21.90	10.40	29.27	1	37.26	32.31	22.68	13.48	17.93	11 94	23.60
Shallow plowing	2	34.74	31.07	24.73	10.56	26.73	1	33 39	29.86	22 35	12.03	17.57	11.59	22 15
Sub-surface packed	2	33 09	31.69	24.88	10 50	28.13	2	35.11	31.74	22.97	13.14	17.82	11.82	22 97
Harrowed after plowing	2	33.69	31.43	24.84	10 41	29.63	2	36.18	32.46	24.65	12.76	18.25	11.58	23.94
Subsoiled 4 and 6 inches	4	39.69	34 03	23.43	12.03	29.79	2	37.86	34.50	21.40	14.86	19.29	13.44	24 54
Subsoiled 8 inches	4	37.40	33.58	24.49	11.43	29.84	2	37.07	33.91	22.16	14.34	18.95	12.88	24.30
Disc plowed	4	39.20	36.24	26.06	11.50	24.68	4	38.97	36.09	26.56	13.44	14.85	12.47	19.78
Rolled after sowing	1	38.44	32.60	23.03	11.62	29.17	1	36.74	30.80	22.31	13.03	20.47	12 32	24.82
Harrowed after sowing	......	....	....	....	....	....	1	33 70	29.80	20.75	13.35	19 40	....	....
Rolled and harrowed after sowing	1	39.15	34.77	21.61	13.05	31.77	1	38.17	30.90	22.53	12.98	19.27	13.01	25 52
Harrowed, wheat 6 inches high	......	....	....	....	....	....	2	37 07	33.91	23.29	13.88	17.87	....	....
Harrowed, wheat 3 inches high	......	....	....	....	....	....	2	37.86	34.50	21.50	13.63	17 55	....	....
* Averages	2½	36.70	33.05	24.32	11.28	28.78	1¾	36.61	32.56	23.02	13.45	18.27	12.34	23.52

*) "Cultivated in rows" not included in the averages.

†) Rainfall in 1898, 7.75 inches; in 1899, 9.60 inches.

TABLE IV.

Summarized Results of the Soil Moisture Study made in Connection with the Cultivation Experiments with Wheat.

FALL PLOWED LAND.

GENERAL METHOD OF CULTURE.	No. of plots in the trial.	CROP OF 1900. Average Moisture. At sowing time: First foot	CROP OF 1900. Average Moisture. At sowing time: Average for 3 feet	CROP OF 1900. Average Moisture. At harvest time, average for 3 feet	CROP OF 1900. Average Moisture. ‡ Water exhausted from 3 feet of soil plus rainfall	CROP OF 1900. Yield of wheat, per acre	CROPS OF 1898, 1899 and 1900. Average Moisture. At sowing time: First foot	CROPS OF 1898, 1899 and 1900. Average Moisture. At sowing time: Average for 3 feet	CROPS OF 1898, 1899 and 1900. Average Moisture. At harvest time, average for 3 feet	CROPS OF 1898, 1899 and 1900. Average Moisture. ‡ Water exhausted from 3 feet of soil plus rainfall	CROPS OF 1898, 1899 and 1900. Yield of wheat, per acre
		per ct.	per ct.	per ct.	in.	bu.	per ct	per ct.	per ct.	in.	bu.
Cultivated in rows	9	25.67	21.12	24.10	8.52	5.28	32.65	29.21	23.57	10.79	15.57
Ordinary plowing	1	21.91	22.87	20.83	9.46	7.13	33.50	29.10	22.87	11.02	16.53
Shallow plowing	1	25.75	22.63	20.01	9.77	5.90	3 .50	29.41	23.03	11.16	17.47
Sub-surface packed	1	21.01	21.67	23.52	7.89	4.97	32.95	28.43	23.35	10.51	17.77
Harrowed after plowing	1	26.03	22.46	19.79	9.41	5.70	32.05	28.21	22.31	10.79	18.08
Subsoiled 4 and 6 inches	2	27.13	23.80	22.54	8.85	6.88	33.71	29.35	22.50	11.13	17.95
Subsoiled 8 inches	2	27.19	23.58	20.48	9.58	5.06	34.14	28.82	22.01	11.15	18.65
Disc plowed	2	32.25	28.49	24.06	10.40	5.44	31.83	32.52	24.73	11.05	16.48
Rolled after sowing	1	27.40	23.48	20. 0	9.09	8.38	33.51	29.18	22.01	11.05	18.03
Harrowed after sowing	1	27.00	24.49	21.31	9.90	5.65	33.15	29.77	23.24	11.13	1 .10
Rolled and harrowed after sowing	1	29.56	23.18	20.32	9.48	6.95	33.99	29.33	21.95	11.38	18.96
Harrowed, wheat 6 inches high	2	27.25	22.47	22.04	8.80	6.24	....	....	....	....	....
* Averages	1⅓	27.13	23.54	21.36	9.37	6.28	33.95	29.42	22.87	11.10	18.14

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* "Cultivated in rows" not included in the averages.

‡ Rainfall in 1900, 8.31 inches for part of the plots, and 8.63 inches for the others; a slight rainfall before sampling was completed at harvest time. The average rainfall for the three crop seasons was 8.45 inches.

TABLE V.

Summarized Results of the Soil Moisture Study made in Connection with the Cultivation Experiments with Wheat.

SPRING PLOWED LAND.

GENERAL METHOD OF CULTURE.		CROP OF 1900.					CROPS OF 1898, 1899 AND 1900.				
		Average Moisture.					Average Moisture.				
		At sowing time					At sowing time				
	No. of plots in the trial.	First foot	Average for 3 feet	At harvest time, average for 3 feet	‡ Water exhausted from 3 feet of soil, plus rainfall	Average yield of wheat, per acre	First foot.	Average for 3 feet.	At harvest time, average for 3 feet.	‡ Water exhausted from 3 feet of soil plus rainfall.	Average yield of wheat, per acre
		per ct.	per ct.	per ct	in.	bu.	per ct	per ct.	per ct.	in.	bu.
Cultivated in rows	1	28.36	20.98	22.22	8.13	13.84	32.93	28.23	23.05	10.42	15.92
Ordinary plowing	1	31.13	23.16	20.75	9.30	12.45	31.41	28.98	22.78	11.06	19.88
Rolled after sowing	1	33.10	26.37	19.55	11.10	9.70	36.09	29.92	21.63	11.92	19.78
Harrowed after sowing	1	32.49	20.46	18.27	9.18	7.10	......	......	......	......	......
Rolled and harrowed after sowing	1	31.93	21.98	18.98	9.96	9.67	36.12	29.55	21.04	11.99	20.24
* Averages	1	32.19	23.22	19.39	9.89	9.73	35.65	29.48	21.82	11.66	19.97

*) "Cultivated in rows" not included in the averages.

‡) Rainfall in 1900, 8.34 inches and 8.63 inches. Average rainfall for the three crop seasons, 8.56 inches.

The method and plan of the cultivation experiments have been already fully described in the bulletins referred to, and it seems only necessary to give here a brief explanation of the tables:

It will be noticed that the experiments have been duplicated upon fall and spring plowed land. Under the head of "General Method of Culture", "Cultivated in rows" stands for the so-called "Campbell system" of growing wheat. The wheat was sown in rows eighteen inches apart and cultivated throughout the season.

"Ordinary plowing" means ordinary deep plowing six to seven inches deep, and this land received only such cultivation as was considered necessary for sowing and covering the wheat.

"Shallow plowing", three to four inches deep as opposed to ordinary deep plowing, received the same cultivation previous to sowing to wheat as did the ordinary plots.

The Sub-surface packed" and "Harrowed after plowing" plots received this extra treatment in the fall or spring immediately after the plowing.

Certain plots have been subsoiled four, six and eight inches below the bottom of the six inch furrow. This treatment was given only once in three years and was begun in the fall of 1896 and the spring of 1897.

The "Disc plowing" as opposed to ordinary plowing was done with a John Deere Secretary disc gang plow.

As a special treatment some plots have been rolled after sowing with a smooth roller, others have been harrowed or rolled and harrowed after sowing, and during the last two years, several plots have received an extra harrowing after the wheat was up three and six inches high.

Under the head of "Average moisture", the percentage of moisture in the first foot of soil at sowing time is given for each set of plots, and the average percentage of moisture in the first three feet of soil is given at sowing time and also at harvest time.

Moisture determinations were made at sowing time usually within a week or ten days after the wheat was sown and at harvest time immediately after the grain was cut. The interval between the taking of the two sets of samples was the period for which the rainfall was recorded and is denoted as the "growth period" for the crop in that season.

In 1898, all the plots were sown between the dates of April 25th and 27th. Soil samples were taken May 3rd to 6th on the fall plowing and May 9th to 12th on the spring plowing. The grain was harvested August 6th to 10th and the soil samples were taken August 10th to 13th from all the plots.

In 1899, the fall plowed plots were sown on April 26th to 28th and the spring plowed plots on May 11th to 13th. The moisture determinations were made from all the plots between the dates of May 10th and 14th. The wheat on the fall plowing was harvested on August 4th to 7th and the soil samples were taken August 7th to 8th. The grain on the spring plowing was harvested August 14th and 15th and the soil moisture determinations were made August 15th and 16th.

In 1900, all the plots were sown April 13th to 16th and the soil samples were taken April 19th to 21st. The grain was harvested on all the plots July 24th to 31st and the soil samples were taken July 25th to 30th.

The loss of water during the period of growth from the first three feet of soil added to the rainfall for the same period gives the relative amount of water used by the crops on the several plots. In the column at the right in each table, the yield of wheat is given in bushels per acre so that a comparison between the inches of water used by each crop and the bushels of grain produced may be easily made.

The columns headed "Averages" are easily understood. The averages at the right of each table show the relation between the several methods of culture upon spring and fall plowed land as an average for a two and three years' trial. From the averages at the bottom of each table the total average results for each year from spring and fall plowed land may be compared.

RESULTS OF CULTIVATION TRIALS DISCUSSED.

It is not the purpose of this bulletin to discuss the relative value of the several methods of cultivation in regard to the crop produced, but to consider the effect upon the moisture condition of the soil, and the relation which the quantity of water used by the crop has to the yield of grain.

The wheat which was cultivated in rows produced the least crop on the average, both on spring and fall plowed land, and there has been no appreciable conservation of soil moisture by this method of culture.

The next smallest yield came from the land which was disc plowed. This ground has shown a relatively high moisture content each season and the smaller comparative yield is not due to a lack of soil moisture. The disc plow did not break and turn all the soil. The stubble was not properly covered and the soil was left in a bad mechanical condition, which accounts for the poorer crops. Notice, in the average for the three years' trial, that it required more water to produce the sixteen-bushel crop on the disc plowed land than it did to produce the eighteen-bushel crop on the ordinary plowing.

The yield from the subsoiled land has averaged a little above that from the ordinary plowing, but it has taken on the average a little more water to produce the crop and these plots have shown less moisture in the soil at the end of the growing season than has the ordinary plowing.

The shallow plowing has produced on the average a bushel to a bushel and a half less wheat than the ordinary plowing, at about the same expense of soil moisture for the production of the crop. With this method of culture as with the disc plowing, the difference in yield is not due to a lack of moisture but due to the physical and perhaps to the chemical condition of the soil. The development of the bacterial life of the soil has much to do with its fertility and productiveness. The bacterial life exists only in the surface soil and mainly perhaps in the mellow moist soil which is cultivated and turned over by the plow from year to year. Shallow plowing for an extended length of time gives less depth of mellow soil, less space for the bacteria to develop in, and less plant food for them to work over. Thus shallow plowed land may gradually become less fertile for the production of crops.

It has taken a little less water on the average to produce the crops on the land which was sub-surface packed after plowing and the soil has contained a higher percentage of moisture at the close of the season than was found in the ordinary plowing, but the special treatment has given no increase in the yield of wheat over the ordinary treatment. Harrowing after plowing has given a small increase in the yield of wheat and it has taken a little less water on the average to produce the crop on these plots.

Rolling and harrowing after sowing have given increased yields of wheat, especially marked on spring plowing, but it has taken more water to produce the crop that it has on the ordinary plowing and the soil has been left drier at the close of the season.

Harrowing the wheat after it was up has been practiced two seasons, 1899 and 1900. In the first trial the yield on fall plowing was increased over two and one-half bushels per acre by harrowing the grain when it was six inches high and beginning to stool. (The harrowed plots are the duplicates of those subsoiled four and six inches.) It took less water to produce this crop than it did to produce the crop on any other plot and at harvest time the ground was left with nearly one and one-half inches more water in the first three feet of soil than was found in the duplicate plots.

On the spring plowing, harrowing the wheat in 1899 saved a little water in the soil but gave no increase in crop.

In 1900, the above trial repeated on fall plowing gave no increase in crop and seemed to have little influence upon the conservation of soil moisture.

A common straight toothed harrow was used in the above trials. The light weeding harrows and spring-tooth weeders which are now on the market are more suitable for such work. When the ground is mellow and rough or at all ridged a heavy harrow can not safely be used. This was made evident by trials on spring plowed land.

Wheat may be harrowed without injury before it comes up or just as it is pricking through the ground. After it is well up, it is better not to harrow until the grain is several inches high and stooling. The plants have then become firmly rooted and are not readily pulled up and the stool will not be so easily covered as the single, slender blade.

A comparison of the average results of the three trials on spring and fall plowed land show that the larger yield of wheat was obtained from the spring plowing. In the spring, the average moisture content of the first three feet of soil has been about the same for each set of plots, but the spring plowing has averaged wetter near the surface than the fall plowing, containing on the average over half an inch more water in the first foot of soil. During the season a little more moisture was exhausted from the soil which was spring plowed and it required a half inch more water to produce the crop. The larger yield, however, more than offsets the larger amount of water used.

The average yields for a seven years' trial of fall compared with spring plowing for wheat—prior to 1900—give a difference of one bushel per acre in favor of fall plowing. (See Bulletin No. 38, page 387.)

WATER REQUIRED TO PRODUCE A CROP.

As an average for the three years' trial, it took 11.1 inches of water to produce 18.12 bushels of wheat on the fall plowed land, or 1 inch of water to 1.63 bushels of wheat. On the spring plowed land, 11.66 inches of water were used in the production of 19.97 bushels of wheat, or 1 inch to 1.71 bushels.

These averages include the results for three very different seasons. The wheat crop was pronounced "good" in 1898, "fair" in 1899 and "very poor" in 1900. Perhaps the crop of 1900 is too much of an extereme to be included in the averages. By comparing the results from the two sets of plots in 1898, it may be seen that it required 11.5 inches of water to produce 28.05 bushels of wheat on fall plowing, or 1 inch to 2.44 bushels; while on spring plowing 11.28 inches produced 28.78 bushels which is 1 inch to 2.55 bushels.

In 1899, on fall plowing, it took 12.21 inches of water to produce 20.17 bushels of wheat, which is at the rate of 1 inch to 1.65 bushels of grain. On the spring plowing, 13.45 inches of water gave a crop of 18.27 bushels of wheat and the rate was 1 inch to 1.36 bushels.

The average for the two seasons will perhaps represent the average North Dakota season better than the average for the three seasons. For the two crops it required on the average 11.83 inches of water to produce 24.04 bushels of wheat on the fall plowed land, which makes one inch of water equivalent to 2.03 bushels of wheat. On spring plowed land, 12.34 inches of water produce 23.52 bushels of wheat and 1 inch was equivalent to 1.91 bushels.

It required a less quantity of water to produce the large crop of 1898 than it did to produce the smaller one of 1899, and it took more water in 1899 to produce the small crop on the spring plowed land than it did to produce the larger one on the fall plowed land.

From the consideration of the above data, it seems safe to conclude that at this Station ten inches of water will be required on an average for the production of a twenty-bushel crop of wheat, and in order to insure the production of such a crop, three or four inches of the required amount of water should be contained, as available water, in the first three feet of soil at the time the grain is sown.

In the spring of 1900, the soil contained on an average four inches less water than it did in the spring of 1898. The rainfall during the growth period was about the same for each year, yet the crop of 1900 averaged only one-third to one-fifth that of 1898.

More rain fell during the growth period in 1899 than in 1898, but the soil contained one and one-half inches less water in the spring of 1899 than it did at seeding time in 1898, and the crop of 1899 was smaller by eight to ten bushels per acre than the crop of 1898.

In 1900 the rainfall was not well distributed, the larger part coming in July, and the following month, too late to give much benefit to the wheat crop, but in 1899 the rainfall was well distributed and the decrease in yield, so far as it may be related to the water supply, seems to have been due to the smaller amount of available water in the soil at seeding time. The data indicate that an inch of available water in the soil may be worth more to the crop than two or three additional inches of rainfall during the growing season.

CONSERVING SOIL MOISTURE BY ROTATION OF CROPS.

Unfortunately no soil samples were taken from any of the rotation plots at seeding time in 1900 so that no comparison can be made between the several plots as to their relative moisture conditions early in the season. On July 24th to 28th, about the time harvest began, moisture determinations were made from all of the cultivation plots and from nearly all rotation plots. The moisture content of the soil was studied to the depth of three feet in each plot. The samples were taken in foot sections with King's soil tube. Table VI gives the percentages of moisture found in the soil of the rotation plots which were being cropped to wheat; plots 1, 2 and 3 of the cultivation series are also included, and the yield of wheat per acre from each plot is given for comparison.

TABLE VI.

Showing Percentages of Moisture in the Soil of Wheat Plots near Harves Time, July 24th to 28th, 1900.

Plot No.	METHOD OF FARMING	MOISTURE PERCENTAGE				CROP 1900
		First foot	Second foot	Third foot	Avg.	bu.
1	Wheat continuously 5 years, plowed shallow, ordinary cultivation	18 91	19.14	21 59	20.04	4.7
2	Wheat continuously 5 years, plowed deep, good ordinary cultivation	18.60	20.92	22.54	20.83	7.1
3	Wheat continuously 5 years, spring plowed, 6 inches deep, good cultivation	18.02	21.90	21.54	20.75	13.2
4	Corn in 1899, previously cropped, as plots 1, 2 and 3	20.88	23.14	24.10	23.04	25.4
7	Corn in 1899, flax in 1898, wheat in 1897, wheat in 1896, corn in 1895 etc	21 48	20.81	21 53	21.29	23.8
8	Wheat continuously since 1883,	19.87	21 95	23.46	22.20	4.0
18	Peas in 1899, previously in wheat,	19 76	20.67	23.55	21.62	7 8
21	Spring rye in 1899, and every third year since 1890	17.78	20.45	25.09	21 98	4 3
22	Barley in 1899, and every third year since 1890	19.54	21.61	22.52	21.48	3 4
27	Timothy in 1898 and 1899, sod plowed in September, 1899	13.80	21.22	24.06	20 28	1.6
1 B	Corn in 1899	20.14	20.99	22.14	20 87	*
2 B	Broom-corn millet in 1899	19.50	22.30	25.44	21 77	*
3 B	German millet in 1899	17.03	21.77	24.67	20.41	*
4 B	Buckwheat in 1899, previously clover and timothy since 1896	21.95	23.29	20 41	22.31	14.7

* Plots 1 B, 2 B and 3 B were harvested together. The average yield was 28 bushels per acre. The crop on the broom-corn millet ground was the best of the three.

Plots 1, 2, 3, 4, 7 and 8 are the same as those described in Diagram I.

Plots 18, 21, 22 and 27 are in the rotation series, but the yields are not shown in Diagram I.

Plots 1 B, 2 B, 3 B and 4 B are not in the same field and are not comparable with the other plots, the soil having been enriched by manuring and by rotation with clover and cultivated crops for several years previous to 1899. The record from these plots is included in the table in order to give more data for comparison.

The above study shows that at the harvest season, the soil in all the plots which were growing wheat was uniformly dry to the depth noted, without regard to the method of farming which had been practiced. It also indicates that to the depth of three feet, the wheat crop is unable, on the average, to exhaust the moisture in this particular soil below 21 per cent. of the dry weight of the soil, in other words, below 21 per cent., the soil moisture is unavailable for the use of the growing wheat. Samples of soil taken at intervals during the dry portion of the season of 1900, from plot 2 described above, showed the following percentages of moisture:

TABLE VII.

Showing Percentage of Moisture in the Soil at Several Dates During the Drouth of 1900.

DATE OF TAKING SAMPLE	April 20th per cent.	May 31st per cent.	June 12th per cent.	June 26th per cent.	July 28th per cent.
First foot	24.02	22.83	20.55	19.12	18.60
Second foot	20.66	22.19	21.60	24.28	20.92
Third foot	23.35	18.94	24.28	23.85	22.54
Average for 3 feet	22.87	21.01	22.34	22.64	20.83
	inches	inches	inches	inches	inches
Rainfall	....	2.61	.67	1.44	3.91
Depth of water table	103.5	10 .5	101.8	101.5	92.5

The section headed "Rainfall" shows the amount of precipitation recorded during the interval between the taking of the samples.

The depth of the water table given above is the actual depth recorded at the date of taking the samples. The water table averaged the lowest from April 20th to May 31st and the moisture determinations indicate that the deeper soil was driest during that period.

Early in July when the wheat was heading, samples of soil taken by Professor Ladd for chemical analysis showed a large difference in the moisture content. Plot 1 B, which had produced a crop of corn in 1899 contained 22 per cent. of water in the first foot of soil, while the wheat continuously land (plot 8) contained only 12 per cent. The large differences in soil moisture observed on July 24th and November 15th in those plots which were farmed to different crops in 1900 indicate that at seeding time there must have been a large difference in the moisture content of the plots sown to wheat in 1900, which had produced different crops in 1899. At harvest time this difference had almost entirely disappeared and the soil moisture had been reduced to about the same level in all the plots by the maturing crop of wheat. It appears that the soil moisture was exhausted from the several plots somewhat in proportion to the crop of wheat produced, and that at maturity practically all of the available moisture in each plot had been used by the crop.

No connected study was made in 1900 of the deeper soil water in these plots, but on November 15th, samples taken to the depth of six feet from three wheat plots (only one of which was in the above series) showed a larger moisture content and a higher water table in plots which had produced the least crops. The study of the root development of the several crops of wheat, as shown in Fig. II, also indicates that the long roots of the large crop would tend to exhaust the deeper soil moisture and lower the water table to a greater degree than would the shorter roots of the small crop. In previous experiments conducted at this Station, increased yields of wheat have been obtained for several years after a rotation with corn or other cultivated crop, and it is probable that in favorable seasons the increased supply of available water in rotated lands is not all exhausted by the first crop of wheat.

ROOT GROWTH OF WHEAT PRODUCED BY DIFFERENT METHODS OF FARMING.

Samples of wheat roots were taken at maturity from three of the several plots shown in Diagram I in order to study the development of the roots in reference to the crop produced. The photo-engraving of these samples is shown in Fig. II.

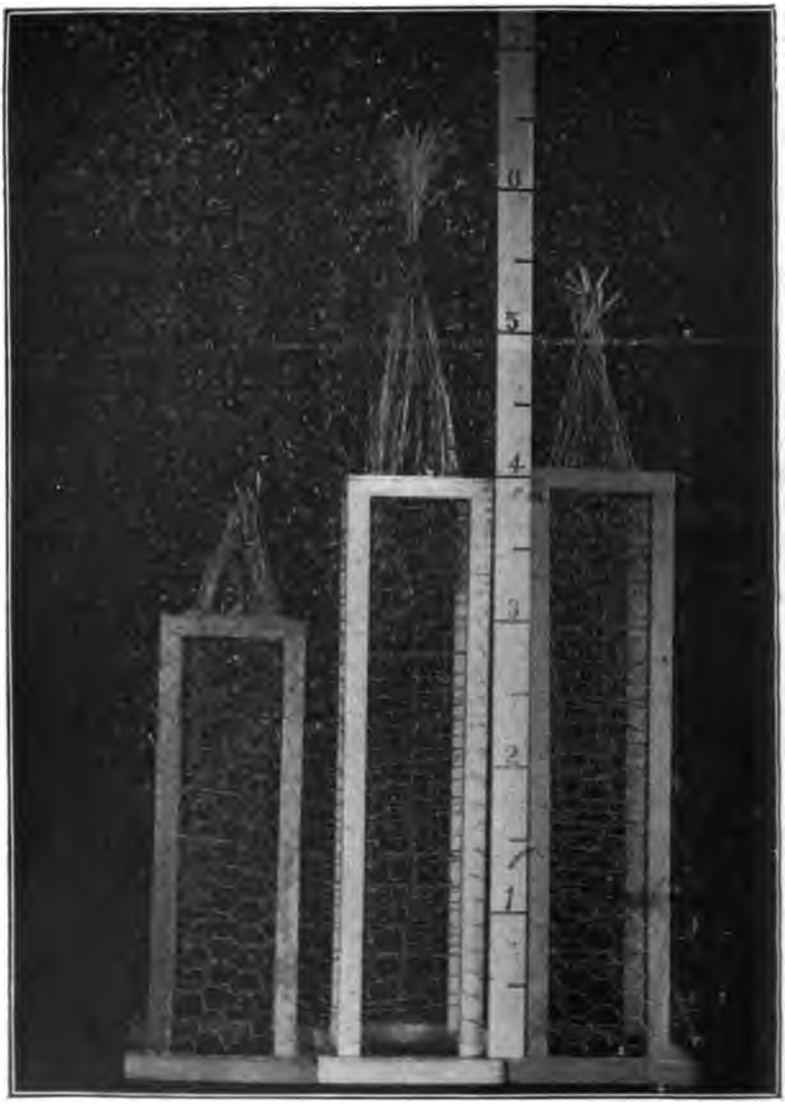


FIG. II—SHOWING SAMPLES OF WHEAT ROOTS OF THE CROP OF 1900.

The sample on the right shows the root growth of the wheat which grew on plot 1, (the poorest crop produced). The sample was taken July 26h, 103 days after planting.

The sample on the left was taken from land farmed in the same manner as described for plot 2, and represents the root development of the average crop produced on the fall plowed, wheat continuously land. The sample was taken July 27th, 104 days after the planting of the seed.

The sample in the middle of the illustration was taken from plot 4 and is an example of the root growth of the largest crop produced and was from land which had produced a crop of corn in 1899. This sample was taken August 1st, 99 days after planting.

No special discussion of this study need be made. The samples show that the root growth varied with the stem growth but not in the same proportion. It was not the fault of the roots that the crop on plot 1 made so poor a growth and so small a yield. Although shorter, the roots of the sample taken from this plot were thicker and more fibrous than those of either of the other samples. The roots occupied the ground fully, but something was lacking in the soil, and the study shown in Diagram II indicates that it was the soil moisture.

RELATIVE EFFECT OF DIFFERENT CROPS UPON THE CONSERVATION OF WATER IN THE SOIL.

Reference has already been made to the study which was begun July 24th, 1900, for the purpose of determining the actual effect of each crop or method of rotation upon the conservation of the soil moisture. Samples of soil were taken as described above to the depth of three feet in each plot. The results of these moisture determinations are given in Diagram II. A large difference in the moisture content of the soil of the several plots was observed, but the study was not considered satisfactory, because the total amount of water which had been conserved in the soil was not shown. A plan was then devised by which a study of the total soil moisture in each plot might be made at the close of the season after the full effect of the rotation had taken place.

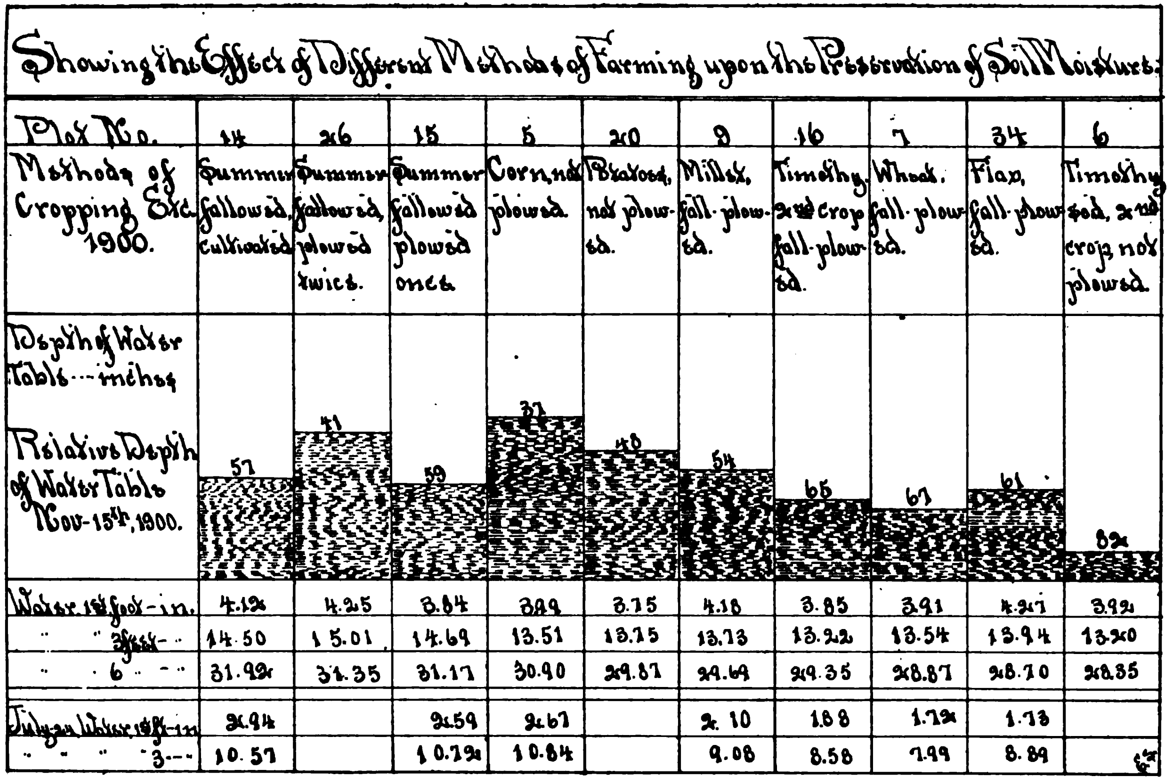
Several common one-and-one-half-inch augers were purchased and provided with shanks of different lengths, the longest being ten feet. The depth of the water table in a wheat field on the Station farm at that date was eight and one-half feet.

The idea was to determine the soil moisture down to, and perhaps below the water table. In his way one should be able to get an exact comparison of the total water content of the soil of the several plots.

The excessive rains in August and September rather discouraged the carrying out of the plan—all the ground seemed to be filled with water—but the study was made late in the fall, as the ground was freezing, and with very successful results. Not withstanding the excessive wet condition, there was still a large difference in the moisture content of the several plots, as shown in Diagram II. One of the most interesting parts of the experiment was the discovery that the height of the water table in the several plots varied in about the same manner as the water content of the soil. The holes which were made in taking the soil samples served as wells by which the distance to the standing water was easily measured.

The results of this whole study are clearly shown in Diagram II. The diagram is divided into vertical columns representing the plots which are numbered in the first horizontal space at the top. Next, the method of summer fallowing or of cropping in 1900 is noted for each plot. In the third horizóntal space, the relative depth of the water table in each plot is shown by the contrast in the height of the darkened columns, and the actual depth is given in inches. Below this representation, the actual amount of water in the soil as determined from the samples is given in inches for each plot. For example, plot 14 contained 4.12 inches of water in the first foot of soil, 14.5 inches in the first three feet of soil and 31.92 inches in the first six feet of soil on November 15th, 1900. This measurement in inches means that if all the water in the soil of plot 14 to the depth of six feet could be taken out and spread evenly over the surface of the ground, its depth would be 31.92 inches. Below the double line the water content of the soil, as determined from the samples taken July 24th is given, also in inches. On that date, plot 14 contained 2.94 inches of water in the first foot, and 10.57 inches of water in the first three feet of soil, which was as deep as the samples were taken.

The plots are arranged in the diagram in the order of their total moisture content (the largest, first) as shown by the moisture determinations, November 15th. It will be noticed that the height of the standing water in the soil does not vary in every case with the total water content. This variation or lack of variation is not easily explained. The capillarity of the soil of the summer fallowed plots seemed to be greater than that of the other plots, and more water was drawn up from below and held in the surface three feet



Showing the Effect of Different Methods of Farming upon the Preservation of Soil Moisture.										
Plot No.	14	26	15	5	20	9	16	7	34	6
Methods of Cropping Etc. 1900.	Summer fallowed, cultivated	Summer fallowed, plowed twice.	Summer fallowed plowed once.	Corn, not plowed.	Potatoes, not plowed.	Millet, fall-plowed.	Timothy, 2nd crop fall-plowed.	Wheat. fall-plowed.	Flax, fall-plowed.	Timothy sod, 2nd crop not plowed.
Depth of Water Table—inches Relative Depth of Water Table Nov-15th, 1900.	57	41	59	37	48	54	65	67	61	82
Water 1st foot—in.	4.12	4.25	3.84	3.99	3.75	4.18	3.85	3.91	4.27	3.92
" " 3 feet— "	14.50	15.01	14.69	13.51	13.75	13.73	13.22	13.54	13.94	13.20
" " 6 " — "	31.92	31.35	31.17	30.90	29.87	29.69	29.35	28.87	28.70	28.35
July 24 Water 1st ft—in	2.94		2.59	2.67		2.10	1.88	1.72	1.73	
" " " 3— "	10.57		10.72	10.84		9.08	8.58	7.99	8.89	

DIAGRAM II.

of soil. In the flax plot, the samples showed a lack of water in the fourth and fifth foot, which brings down the total water content below that found in the wheat plot, although, by the height of the water table, flax should be ranked next to millet as a conserver of soil moisture.

Grass crops are not conservers of soil moisture and when used as a rotation for wheat, the sod should be plowed in summer as soon as the hay crop is secured. Plot 16, which in July was comparable to plot 6 was not plowed until October 5th, yet the late growth of grass on plot 6 used up one inch of water which was saved by plowing down the grass on plot 16.

Leaving out of the discussion for the present the effect of the different methods of summer fallowing, it will be observed that of all the crops, corn has left the most water in the soil for the use of next year's wheat crop; an inch more than potatoes, over an inch more than millet and two inches more than wheat or flax. It may be stated here that the crops on the several plots were considered normal for the year in which they were produced.

IMPORTANCE OF THE CONSERVED MOISTURE.

At first thought, two inches more water does not seem a large amount when one is considering such quantities as appear in the soil of these plots, but a little calculation will show that two inches of water conserved in the soil, just where it is needed for the use of the crop, means a great deal: 28.87 inches of water in the first six feet of soil, as found in the wheat ground, plot 7, is equivalent to 31.29 per cent. of the dry weight of the soil, 80 pounds being taken as the average dry weight of the soil per cubic foot and 62.42 pounds as the weight of a cubic foot of water. According to our previous observations, (See Table VI), about two-thirds (21 per cent. of the dry weight of the soil) of this seemingly large amount of soil moisture cannot be used in the production of a crop of wheat. That is, out of the whole 28.87 inches only nine and one-half inches can be used to produce wheat. Two inches added to nine and one-half inches means an addition of over twenty per cent. to the available water in the soil.

Again, we find that one inch of water covering an acre in extent is equivalent to 113.29 tons in weight. Two inches is equivalent to 226.58 tons of water per acre. Hellriegel of Prussia found that it took 338 tons of water to produce one ton of dry wheat crop. At this rate, 226½ tons of water should produce two-thirds of a ton of dry wheat crop. If forty per cent. of the crop is grain, that means nearly nine bushels of wheat more per acre by the addition of two inches of water. Or suppose that it takes 400 tons of water to produce a ton of dry wheat crop, as Professor King's experiments in Wisconsin indicate, then an increase of 226½ tons of water is equivalent to seven and one-half bushels more wheat per acre. That is, plot 5, which produced a crop of corn in 1900 is capable, from the moisture standpoint alone, of producing seven and one-half bushels more wheat per acre in 1901 than plot 7 which was cropped to wheat in 1900.

If the fall had been drier, there is no question but that the difference in the amount of soil moisture conserved by the crop rotation would have been greater. This is indicated by the samples taken July 24th. At that date the corn ground contained 2.85 inches more water in the first three feet of soil than the wheat ground did. The depth of the water table in the wheat plot, at that time, was over eight and one-half feet. It is safe to assume that the total difference in the moisture content of the two plots was double that shown in the first three feet of soil, and that plot 5 contained 5.7 inches more water than plot 7, which means a capacity of eighteen and one-half bushels more wheat per acre, and that is about the difference in the crops produced on plots 2 and 4 in 1900. (See Diagram II.)

In the experiments conducted at this Station, (see page 752) one inch of water was required on the average to produce two bushels of wheat when the total rain fall during the growing period of the wheat was included with the water exhausted from three feet of soil. It was observed, however, that an inch more available water in the soil was of greater value in the production of a crop than an extra inch of rainfall and judging from these experiments, the value of two extra inches of available water in the soil may safely be placed equal to eight or ten bushels of wheat per acre.

MOISTURE CONDITION IN THE SPRING OF 1901.

In the spring of 1901, at sowing time, May 1st to 4th, soil moisture determinations were made from each of the plots described in Diagram II. The data obtained from this study are given in Table VIII.

TABLE VIII.

Showing Water Content of the Soil and Depth of the Water Table in the Spring of 1901 in Rotation Plots, which were Subjected to Different Methods of Farming in 1900.

PLOT NO.	15	16	5	20	26	34	7	14	9	6
METHOD OF CROPPING, ECT. IN 1900.	Summer fallowed, plowed once.	Timothy, second crop, fall plowed	Corn, not plowed.	Potatoes, not plowed.	Summer fallowed, plowed twice.	Flax, fall plowed.	Wheat, fall plowed.	Summer fallowed, cultivated.	Millet, fall plowed.	Timothy sod, second crop, not plowed.
	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches
Total water in first foot	4.09	4.18	3.88	3.75	3.73	4.16	3.60	3.85	3.77	3.73
Total water in first three feet	14.56	14.48	14.23	14.32	13.77	13.86	12.98	13.44	13.74	12.23
Total water in first six feet	31.32	30.72	30.56	30.55	29.75	29.59	29.26	28.97	28.47	27.74
Depth of water table	71.0	78.0	29.5	29.0	74.0	42.0	73.0	78.0	77.0	64.0

For description of table see Diagram II, page 759.

The plots are arranged in the table in the order of their total moisture content. The order of the plots is not the same as it was in the fall. Some plots have gained in moisture while others have lost. The most abnormal changes have occurred in the summer fallowed ground and in plot 16. With the exception of plots 14 and 16 which have practically changed places, there is the same general relation between the plots as there was last fall, in that those which averaged highest in moisture at that time are still highest and those which averaged lowest are still in that condition.

A few suggestions may perhaps explain to some exetent the abrupt changes which have occurred in the soil moisture of some of the plots. Plot 15 was not cultivated. The weeds were cut on this plot and it went into the winter condition with a thick covering of pigeon grass. Plot 16 was timothy sod plowed in October and was thus left in a loose, open condition. Both of these plots were therefore in a condition to gain moisture during the winter season.

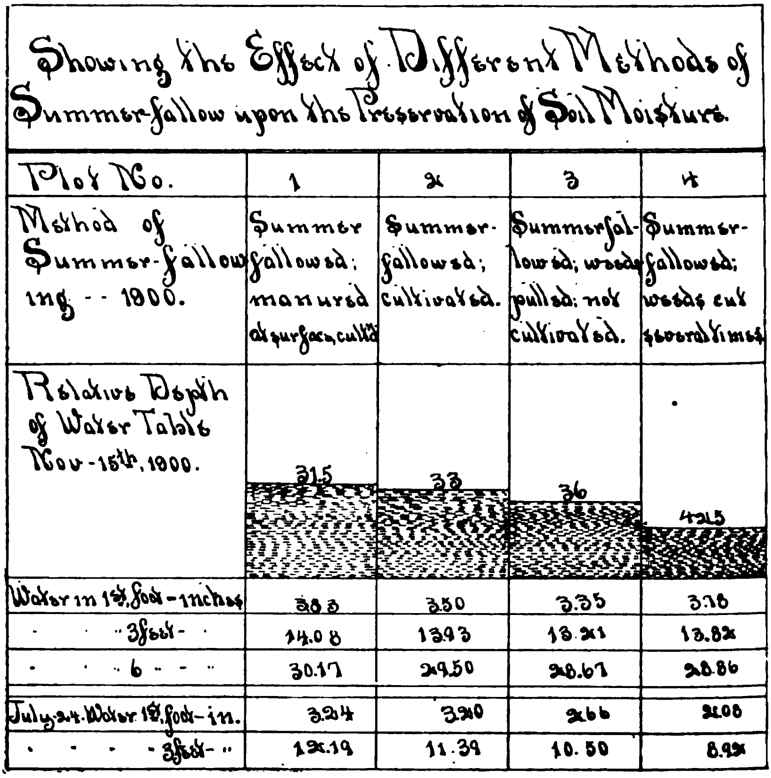
Plot 26 was plowed in August the last time and plot 9 was fall plowed early in September. The soil of these plots thus became more compact near the surface than that of the plots plowed later. This condition would tend to make them average higher in moisture last fall.

Plot 14 was plowed August 4th, 1900, and was kept cultivated. Thus the ground showed a high moisture content November 15th, but the surface was smooth and compact when the ground froze. Plots 5 and 20 were not plowed and the surface soil was hard and compact, but the stubble and the vines and the ridged condition of the ground acted as a sort of cover and catch for snow and rain.

There was a slight fall of snow during the winter, equal to about one inch of water. In March a heavy rain fell just as the frost was beginning to come out of the ground. Wherever the surface was smooth and hard the water was quickly drained off and very little moisture was added to the soil. An inch and a half of rain fell in April before the plots were cultivated.

The excessive wetness last fall and the condition of the soil during the winter and spring have thus given an advantage to some plots and a disadvantage to others which would not have occurred in an ordinary season. It will be observed that the water table has fallen in most of the plots, but that in plots 5, 20, 34 and 6 it has risen. No explanation is offered for this observed great difference in the height of the water table. The frost was not out of the ground at the dates the measurements were made, May 9th and 15th, and ice was observed in the auger holes in plots 5 and 20 at the depth of three feet.

A SPECIAL STUDY OF THE EFFECT OF SUMMER FALLOWING UPON THE SOIL MOISTURE.



Showing the Effect of Different Methods of Summer-fallow upon the Preservation of Soil Moisture.

Plot No.	1	2	3	4
Method of Summer-fallowing -- 1900.	Summer fallowed; manured at surface, cult'd	Summer-fallowed; cultivated.	Summerfallowed; weeds pulled; not cultivated.	Summer-fallowed; weeds cut several times
Relative Depth of Water Table Nov. 15th, 1900.	31.5	33	36	42.5
Water in 1st foot—inches	3.83	3.50	3.35	3.18
" " 3 feet "	14.08	13.93	13.21	13.82
" " 6 " "	30.17	29.50	28.67	28.86
July 24. Water 1st foot—in.	3.24	3.20	2.66	2.08
" " 3 feet "	12.19	11.39	10.50	8.92

DIAGRAM III.

Diagram III represents the results of a special study of the conservation of moisture in the soil by different methods of summer fallowing. The plots represented were small in extent—20 feet square—and were laid out in a single series in the order in which they are numbered. The ground upon which the experiment was made, produced a crop of buckwheat in 1899 and was previously in grass. (See plot 4 B, described in Table VI.) The ground was fall plowed in 1899 and received no plowing in 1900, the plots being subjected to a bare summer fallow as described in the diagram.

All of the plots were harrowed alike on May 1st, and plot 1 was given a surface dressing of well rotted stable manure at the rate of about 40 tons to the acre. This was thoroughly pulverized into the soil on May 3rd, plot 2 also receiving the same cultivation as plot 1. During the summer, until August 1st, plots 1 and 2 were cultivated on an average every two weeks. After the rains began, the plots were not regularly cultivated and received no cultivation whatever after September 15th.

The weeds were pulled on plot 3 on June 1st, and thereafter it was kept perfectly bare. The weeds on plot 4 were cut three times during the season, so as to keep them from seeding. and the refuse was raked off the plot. On November 15th, plot 4 was covered with a thick mass of pigeon grass six to eight inches high. On this date the surface of plots 1, 2 and 3 was bare and hard.

Moisture samples were taken from these plots at intervals throughout the season. Several samples taken May 1st indicated about the same moisture content in the first three feet of soil for all of the plots. The first complete set of samples was taken May 10th. At that date the soil of plot 1 contained a slightly greater per cent. of water in the first foot than was found in the soil of the other plots. The samples taken May 30th showed no marked variation between the several plots in the moisture content of the soil. The percentages of moisture found in the soil of the several plots on June 26th is given in the following table; the record from an adjacent wheat plot is also included for comparison:

TABLE IX.

Showing Moisture in Summer Fallowed Plots, June 26, 1900.

Plot No.	METHODS OF SUMMER FALLOWING, ETC.	MOISTURE PERCENTAGE			
		First foot	Second foot	Third foot	Average
1	Manured and cultivated	31.30	26.18	25.52	27.79
2	Cultivated	25.00	23.22	24.81	24.30
3	Not cultivated, weeds pulled	22.66	27.47	24.72	25.13
4	Not cultivated, weeds cut	19.01	22.08	25.82	22.60
5	Cropped with wheat	19.12	24.28	23.85	22.64

It will be observed from the table that on this date, the manured and cultivated ground showed a decided advantage in moisture content over any of the other plots. Plot 4, summer fallowed but not cultivated, had practically the same moisture in the soil as did the ground adjacent which was being cropped to wheat.

A set of moisture samples was taken on July 24th, and on November 15th a final determination of the total moisture content of the soil to the depth of six feet was made for each plot; the height of the water table was also noted at that time. The data obtained by these studies are given in Diagram III, which needs no explanation, its arrangement being similar to that of Diagram II already described. It will be observed from Diagram III that on July 24th the manured and cultivated ground contained eight-tenths of an inch more water in the first three feet of soil than the cultivated plot, while the latter contained nine-tenths of an inch more water than the plot which was kept clean but received no cultivation, and two and one-half inches more than the summer fallowed ground which received neither cultivation nor weeding. According to previous calculations, the total difference in soil moisture between plots 2 and 4 at this date was about five inches of water, that is, on July 24th, 1900, the cultivated summer fallow was capable from the moisture standpoint alone of producing sixteen bushels more wheat per acre in 1901 than the land which was being summer fallowed without cultivation. From the standpoint of conserving soil moisture "shiftless" summer fallowing with no cultivation is only a little better than continuous wheat cropping. (Compare records for plot 4, Diagram III and plot 7, Diagram II.)

On November 15th, after the heavy rains, the difference in the total moisture content of the soil in the several plots was not so great as it appeared on July 24th, yet the variation in the height of the water table is apparent to the eye and the difference in total moisture content between plots 1 and 2 and between plots 2, 3 and 4 is great enough to be equivalent to several bushels of wheat should the season of 1901 prove to be dry. The small size of these plots should tend to cause them to show less difference in height of water table and total moisture content than would be shown by larger areas.

Prior to the rainy season, more water was conserved in plot 3 than in plot 4. The fall determinations, however, showed the greater water content in plot 4. The accumulation of water in this plot was largely in the first three feet of soil and was evidently due to the mulch of dead pigeon grass. During the growing season the weeds exhausted the moisture more than the evaporation from the bare fallow did; after frost the covering made by the weeds acted as a mulch to conserve the moisture and the loss of water was then greater from the bare fallow.

Moisture samples were taken from the above plots May 7th, 1901. At that date the total moisture content was highest in plot 1 and lowest in plot 4, while plots 2 and 3 were practically alike. The manured ground was especially wet in the surface two feet of soil. The height of the standing water was as follows: Plot 1, 38 inches; plot 2, 34½ inches; plot 3, 33 inches, and plot 4, 35 inches.

EFFECT OF MANURING UPON THE CONSERVATION OF SOIL MOISTURE.

From the data presented in Diagram III it is evident that a heavy surface dressing of well rotted manure pulverized into the soil acts as a conserver of the soil moisture on land which is being summer fallowed. No complete study of the effect of manuring upon the soil moisture when a crop was being produced has been made at this Station. A considerable experiment in this line was conducted in 1900 but the moisture determinations were only made to the depth of three feet, the data obtained, however, indicate that in a dry season, manuring the soil which was cropped had the effect of causing larger quantities of soil moisture to be exhausted from the manured land than from the land which received no manure.

Table X shows the percentages of moisture found in the soil of several manured and unmanured plots on July 24th, 1900.

The manured plots produced an average of one and two-tenths bushels more crop, but showed one and two-tenths per cent. less moisture in the first three feet of soil.

This study was continued in the spring of 1901. Samples were taken to the depth of eight feet from several of the manured and unmanured plots. The results are given in Table XI.

TABLE X.

Showing Percentages of Moisture Found in the Soil of Manured and Unmanured Ground on July 25th and 26th, 1900.

Plot No's.	METHOD OF MANURING, ETC.	Rate per acre	Crop grown in 1900	Yield per acre		Moisture in 1st foot		Moisture in 2nd foot		Moisture in 3rd foot		Moisture, average for 3 ft.	
				Manured	Unmanured	Manured	Unmanured	Manured	Unmanured	Manured	Unmanured	Manured	Unmanured
		tons		bu.	per ct.	per ct.	per ct.	per ct	per ct	per ct.	per ct	per ct.	per ct.
1 and 2	Fall plowing, surface dressed, May 1, 1900	40	Fallowed, cultivated	......	......	33.67	32.45	29.66	27.29	28.57	26.60	29.98	28.22
4 and 14	Plowed under in fall, 1899	6	fallowed, cultivated	......	......	30.34	30.62	23.40	23.03	26.57	25.78	26.29	26.17
6 and 5	Plowed under in fall, 1899	6	corn	†39.6	34.7	21.64	27.76	26.00	26.55	25.77	26.51	24.70	26.86
10 and 9	Plowed under in fall, 1899	6	millet	†......	......	20.04	21.80	21.62	22.47	24.56	22.81	22.54	22.45
29*	Plowed under in spring, 1900	15	flax	9.4	7.3	21.65	22.88	24.56	28.00	27.48	31.39	24.95	27.41
30*	Plowed under in fall, 1899	15	flax	6.1	7.8	21.01	21.48	27.29	24.60	25.18	27.43	24.57	24.52
4*	Plowed under in fall, 1899, harrowed after plowing	13	wheat	14.9	9.8	17.82	18.53	19.34	26.41	20.76	27.02	19.39	24.39
5*	Plowed under in fall, 1899	13	wheat	10.9	12.7	18.51	19.58	20.33	20.87	20.71	22.91	19.93	21.33
15*	Fall plowed, surface dressed in fall with fresh manure	13	wheat	6.1	7.3	17.43	17.68	21.00	22.60	22.98	26.42	20.74	22.24
19*	Fall plowed, surface dressed in fall, 1899	13	wheat	10.1	9.0	17.45	17.19	19.71	20.81	20.67	23.07	19.55	20.87
	Average	14	.. ..	13.9	12.7	21.96	23.00	23.29	24.27	24.33	26.09	23.26	24.45

*) The single plots were divided, one half being manured and the other half left as a check

†) The records for yield of fodder were lost in the fire, which burned the College barn January 4th, 1901. It was estimated at the time of cutting that the manured plots would yield sixteen per cent. more millet hay and twelve and a half per cent. more corn fodder than the unmanured ground.

TABLE XI.

Showing Percentages of Moisture Found in the Soil of Manured and Unmanured Ground on May 13th, 1901.

Plot No's.	METHOD OF MANURING, ETC.	Rate per acre	Crop grown in 1900	Moisture in 1st foot		Avg. Moisture in first 3 feet		Avg. Moisture in second 3 feet		Avg. Moisture in first 6 feet		Avg. Moisture 7th and 8th foot		Avg. Moisture in first 8 feet	
				Manured	Unmanured	Manured	Unmanured	Manured	Unmanured	Manured	Unmanured	Manured	Unmanured	Manured	Unmanured
		tons		per ct.	per ct	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per c.t	per ct.
1 & 2 *	Fall plowing, surface dressed in 1900, not plowed	40	fallowed, cultivated	40.12	36.56	34.06	30.08	30.15	29.74	31.86	30.04	37.05	34.58	33.27	31.33
4 & 14 *	Plowed under in fall 1899, fall plowed 1900.	6	fallowed, cultivated	40.71	40.04	36.47	33.29	29.52	29.83	32.91	31.39	30.80	34.54	32.36	32.57
6 & 5	Plowed under in fall 1899, not plowed ..	6	corn	40.31	40.39	33.30	35.24	30.39	31.26	31.76	33.12	34.16	33.21	31.89	33.14
10 & 9	Plowed under in fall '99 fall plowed 1900. ...	6	millet	41.70	39.29	35.05	34.02	27.60	28.17	31.19	30.85	30.55	31.01	31.03	30.89
30	Plowed under in fall 1899, not plowed...	15	flax	41.91	38.31	36.38	35.63	30.19	29.72	32.81	32.19	42.08	43.97	36.70	35.88
4	Plowed under in fall '99, fall plowed 1900..	13	wheat	37.10	38.88	33.08	35.08	31.12	30.09	31.09	32.44	39.03	35.79	33.82	33.60
19	Surface dressed in fall 1899, fall plowed 1900.......	13	wheat	40.29	37.95	38.58	31.93	33.40	32.17	35.13	33.29	36.50	45.56	35.74	36.83
	Average	14	....	40.30	38.77	35.29	34.01	30.34	30.27	32.56	31.90	35.75	36.95	33.51	33.46

*) The moisture samples were taken from plots 1 and 2 on May 7th and from plots 4 and 14 on May 1st.

It will be noted that with two exceptions, (Plots 6 and 4) the manured ground contained more water in the first foot and in the first three feet of soil than the unmanured ground, the average increase being one and one-half per cent. (calculated upon the dry weight of the soil) in the first foot and one and one-fourth per cent. in the first three feet in favor of the manured ground. In the second three feet the moisture averaged about the same for all plots. In the seventh and eighth foot the manured ground was slightly the wettest while the average for the whole eight feet gave nearly the same for both series of plots. The effect of manuring has been to draw up the lower soil water and hold it nearer the surface.

The depth of the water table was noted at different dates in the several plots as follows:

DEPTH OF WATER TABLE IN INCHES.

	Manured	Unmanured
May 9th:		
Plots 1 and 2	38.0	34.5
Plots 4 and 14	24.5*	78.5
Plots 6 and 5	31.0*	29.5*
Plots 10 and 9	93.0	77.0
June 3rd:		
Plots 4 and 14	42.5	56.0
Plots 6 and 5	44.0	42.5
Plots 10 and 9	55.0	50.0
Plot 30	36.0	38.0
Plot 4	51.0	51.5
Plot 19	39.0	39.0

The measurements for depth of water table were made through the auger holes from which the moisture samples were taken. On May 9th the holes in the plots marked with an asterisk were closed with ice which formed within two or three feet of the surface of the ground and usually with a little water above it, which was taken as the surface of the standing water in the soil. On June 3rd no ice was observed and there was no marked variation in the depth of the water table in the several plots which would indicate that the early observations were abnormal and perhaps incorrect.

EFFECT OF THE WINTER SEASON UPON THE SOIL MOISTURE.

Beginning with the winter of 1897-8 a study has been made of the moisture condition of the soil of several plots at intervals during the winter season. The first moisture determinations were made in each trial about the middle of November when the ground was frozen or beginning to freeze at the surface. These trials afford a comparison of the moisture condition of the soil during the winter season between wheat stubble not plowed and fall plowing, between fall plowing left rough and fall plowing harrowed immediately after plowing and between wheat stubble and timothy sod.

In the first three trials the moisture determinations were made to the depth of three feet and the depth of the water table was noted only in one wheat plot, i. e., in the stubble ground. During the past winter the moisture was determined in each foot of soil to the depth of eight feet in November and March and to the depth of six feet in January and February. All samples were taken with the auger. The tabulated results of this study are given in Tables XII, XIII and XIV.

The tables need little explanation. Table XII represents the results of two trials. The percentage of moisture found in each foot of soil at the several dates and the average percentage for three feet is given for each plot. At the right are given the differences (gain or loss) in moisture percentage which occurred between the middle of November and the middle of March. At the bottom of the table is noted the depth of the water table, as recorded at the several dates when the moisture samples were taken, and the amount of precipitation which occurred in the interval between the several dates. In the "gain or loss" column the total precipitation and the total rise or fall of the water table during the winter is given.

Table XIII gives the data secured in the winter of 1899-1900. The average gain of moisture in each foot of soil and the total gain in inches as an average for the three trials are given in the columns at the right.

Table XIV gives the results of the trial for the winter of 1900-1901. In this trial moisture determinations were made in each foot of soil to the depth of six or eight feet. In the table the percentage of moisture found in the first foot of soil and the average percentage in the first three feet, in the second three feet and in the first six feet for each of the several plots is given on each date at which moisture samples were taken. The average moisture in the seventh and eighth foot and the total average moisture for the whole eight feet of soil are given at the beginning and close of the winter season, i. e., November 16th, 1900, and March 15th, 1901. The gain or loss in moisture during the winter is shown in the columns at the right. The depth of the water table in inches at the date the moisture samples were taken is given for each plot and the precipitation during the intervals between the taking of the samples is show at the bottom of the table.

In this trial there was a gain of moisture during the winter in the first foot of soil in three of the plots; plot 32 (fall plowed and left rough) lost about one-tenth of an inch. The total average gain over loss for all the plots was small, being only two-tenths of an inch of water.

There was a considerable gain of moisture in the first three feet of soil in plot 7 (fall plowed and harrowed) and plot 8 (wheat stubble not plowed), the other two plots showed a slight loss. The total average gain over loss was three-tenths of an inch.

In the second three feet two plots showed a slight loss while two others indicated a small gain in moisture. The average equals a total loss per plot of fifteen-hundredths of an inch.

For the six feet, plot 7 made a gain of nearly two and four-tenths inches, plot 8 made a slight gain while plots 32 and 6 lost in moisture. The difference gives a total average gain of a little over one-fourth of an inch. Throwing out plot 7, however, gives a total average loss for the other plots of three-tenths of an inch.

Plots 7 and 6 gained slightly in the seventh and eighth foot, while plots 32 and 8 lost, the total loss over gain being about two inches, which gives an average loss per plot of one-half of an inch.

In the whole eight feet all the plots lost moisture except plot 7, which has made a remarkable gain of nearly two and one-half inches of water. Comparing all the plots gives a total average loss over gain of three-tenths of an inch.

It will be noted that in plot 7 the soil has gained in moisture in every foot, while the soil of the other plots has gained moisture in the surface three feet and lost it at lower depths.

The results of the four trials show that the soil gains moisture during the winter in the surface three feet. This gain does not come from the rain or snow fall; as the precipitation has not been great enough to give the increase in soil moisture recorded, and, the precipitation was mainly in the form of snow from which very little moisture could have entered the soil. The increase of water in the surface soil may be due to a translocation of moisture from below upward, as the ground freezes; the falling of the water table would indicate that such is probably the case. The fact that the moisture content of the first three feet of soil continued to increase, in many instances, after the ground was frozen several feet deep and the further observation from the trial made during the winter of 1900-1, that no appreciable decrease of the moisture content in the lower soil took place while in one instance an increase at all depths was observed indicate that this gain in moisture in the surface soil may come from some source other than the soil and water table beneath. The increase may be due to a condensation of the atmospheric moisture from the air which passes into and out of the soil.

This winter moisture study leads to the conclusion that at this Station there is little or no absolute loss of moisture from the soil during the winter season and that there may be an actual gain of moisture to the soil, and that there is a gain of moisture in the surface three feet of soil.

ACKNOWLEDGMENTS.

The several hundred soil samples required for the moisture study described in this bulletin were taken by Mr. Louis F. Seneco who has rendered efficient assistance in field work.

The original drafts for the diagrams are the work of Mr. E. G. Scholander, an agriculture student in the College.

TABLE XII.

Showing Percentage of Moisture in the Soil During the Winter Seasons of 1897, 1898 and 1899.

DESCRIPTION OF SOIL	Depth of taking sample.	DATE OF TAKING SAMPLE					Gain or loss during winter	DATE OF TAKING SAMPLE			Gain or loss during winter
		Nov. 15, 1897	Dec. 24, 1897	Jan. 24, 1898	Feb. 19, 1898	Mar. 16, 1898		Nov. 8, 18 8	Feb 17, 1899	Mar. 22, 1899	
Plot No.	feet	Moisture per ct.	Moisture per ct.	Moisture per ct.	Moisture per ct.	Moisture per ct.	Moisture per ct.	Moisture per ct.	Moisture per ct.	Moisture per ct.	Moisture per ct
1. Wheat ground, fall plowed, left rough	1 2 3	20.17 24.76 27.85	27.38 26.31 29.31	25.37 25.27 29.14	25.49 25.21 29.90	32.07 26.52 30.94	+ 2.90 + 1.70 + 3.09	35.78 25.84 23.93	39.83 21.48 22.50	39.74 27.40 24.16	+ 3.95 + 1.45 + 0.73
	Avg.	26.90	27.67	26.73	27.02	29.51	+ 2.61	26.98	27.49	29.32	+ 2.38
2. Wheat stubble seeded to timothy and clover, not plowed	1 2 3	28.79 29.79 32.20	28.81 30.47 31.57	27.41 27.71 31.83	22.28 29.88 33.11	30.36 32.42 35.22	+ 1.57 + 2.63 + 3.02	33.[illegible]6 24.43 24.91	37.27 21.99 23.74	30.05 22.16 29.90	+ 5.30 —2.27 + 4.90
	Avg.	30.35	30.28	29.30	28.80	33.03	+ 2.48	27.43	27.48	30.62	+ 3.19
3. Wheat stubble, not plowed	1 2 3	31.48 11.55 29.52	31.36 31.41 29.11	31.42 31.64 31.51	32.03 30.93 31.76	40.48 31.47 31.57	+ 9.00 + 2.02 + 5.05	37.8[illegible] 21.66 23.[illegible]3	43.47 20.02 29.46	40.36 2[illegible].85 28.61	+ 2.47 + 2.19 + 4.98
	Avg	30.73	30.63	31.55	31.52	35.14	+ 5.41	28.06	33.52	31.04	+ 2.98
		inches	inches	inches	inches	inches	inches	inches	inches	inches	inches
Precipitation		......	0.00	0.10	0.10	0.00	+ 0.10	......	0.70	1.11	+ 1.81
Depth of water table		55.7	58.4	67.1	75.0	7[illegible]	—0.3	93.5	98.0	93.0	+.05

TABLE XIII.

Showing Percentage of Moisture in the Soil During the Winter 1899–1900, and the Average and Total Increase of Soil Moisture as an Average for the Three Trials.

DESCRIPTION OF SOIL.	Depth of taking sample	DATE OF TAKING SAMPLE					Gain or loss, during winter	Gain or less, Avg. for 3 winters	Total increase of water in 3 feet of soil, Avg. for 3 winters
		Nov. 15, 1899	Dec. 20, 1899	Jan. 7, 1900	Feb. 28, 1900	Mar. 30, 1900			
Plot No.	feet	Moisture per ct.	Moisture p r ct.	Moisture per ct.	Moisture per ct.	Moisture per ct.	Moisture per ct,	Moisture per ct.	inches
1. Wheat ground, fall plowed, left rough.	1 2 3	31.47 23.13 25.03	.... 22.99 24.63	35.36 27.22 25.32	30.99 23.90 25.03	39.02 29.16 25.01	+ 6.55 + 6.03 + 0.57	+ 4.47 + 3.08 + 1.46	....
	Avg.	25.80	....	28.40	26.10	29.37	+ 3.57	+ 2.85	1.75
2. Timothy and clover sod, not plowed.	1 2 3	25.71 21.10 22.45	33.01 23 07 22 75	31.45 24.73 23.24	29.26 23.37 27.37	34.18 23.61 25.81	+ 8.47 + 2.51 + 3.38	+ 5.14 + 0.96 + 3.79	....
	Avg.	22.77	24.74	26.14	26.10	27.21	+ 4.44	+ 3.37	1.36
3. Wheat stubble, not plowed.	1 2 3	35.01 23.72 23.13	34.75 26.71 25.14	53.31 [illegible] 26.34	46.32 24.94 22.98	48.59 26.07 24.72	+13.58 + 2.35 + 1.59	+ 8.35 + 2.49 + 3.38	....
	Avg.	25.51	27.47	30.80	27.30	30.33	+ 4.82	+ 4.40	1.77
		inches	inches	inches	inches	inches	inches	inches	inches
Precipitation		....	0.50	0.53	0.56	1.23	+ 2.82	+ 1.61	....
Depth of water table		91.0	95.0	96.0	....	10 .0	—7.0	—8.93	....

TABLE XIV.

Showing Percentage of Moisture in the Soil and the Gain or Loss During the Winter of 1900—1901.

DESCRIPTION OF SOIL.	Depth of sample	Date of taking samples Nov. 16, 1900 Moisture	 Jan. 15, 1901 Moisture	 Feb. 15, 1901 Moisture	 Mar. 15, 1901 Moisture	Gain or loss during winter Moisture	Total gain or loss of water during winter
Plot No.	feet	per ct.	per ct.	per ct	per ct.	per ct.	inches
32. Wheat ground, fall plowed, left rough	1st foot . ..	40.72	45.07	40.81	39.60	—1.12	—0.11
	1st 3 feet ...	32.98	35.17	33.34	32.48	—0.50	—0.20
	2nd 3 feet .	29.22	31.04	29.18	29.83	+ 0.17	+ 0.09
	1st 6 feet ...	31.10	33.31	31.07	31.08	—0.02	—0.02
	7th-8th foot	35.90	....	....	33.68	—2.22	- 0.77
	1st 8 feet ...	32.45	....	....	31.75	—0.70	—0.50
		inches	inches	inches	inches	inches	
Depth of watertable		71.0	71.0	77.5	83.0	—12.0	
		per ct.	per ct.	per ct.	per ct.	per ct.	
7. Wheat ground, fall plowed, harrowed after plowing	1st foot......	40.64	49.91	36.03	43.52	+ 2.88	+ 0.23
	1st 3 feet ...	32.38	30.93	32.83	35.53	+ 3.15	+ 1.27
	2nd 3 feet ..	29.64	31.42	30.08	31.47	+ 1.83	+ 0.95
	1st 6 feet ..	30.65	33.91	3[illegible].31	33.20	+ 2.55	+ 2.35
	7th-8th foot	34.07	....	....	34.83	+ 0.76	+ 0.20
	1st 8 feet ...	31.65	....	....	33.66	+ 2.01	+ 2.47
		inches	inches	inches	inches	inches	
Depth of water table............		67.0	65.0	76.5	85.0	—18.0	
		per ct.	per ct.	per ct.	per ct.	per ct.	
8 Wheat stubble, not plowed	1st foot......	40.37	45.27	47.48	44.61	+ 4.24	+ 0.41
	1st 3 feet ..	33.89	35.01	3[illegible].15	34.90	+ 1.01	+ 0.44
	2nd 3 feet...	30.55	30.46	27.16	29.60	—0.95	—0.49
	1st 6 feet ...	32.04	32.58	29.04	32.03	+ 0.09	+ 0.08
	7th-8th foot	38.82	....	....	33.43	—5.39	—1.86
	1st 8 feet ...	34.04	....	....	32.42	—1.62	—1.99
		inches	inches	inches	inches	inches	
Depth of water table............		62.0	67.0	76.0	80.0	—16.0	
		per ct.	per ct.	per ct.	per ct.	per ct.	
6. Timothy sod, not plowed	1st foot ...	40.71	43.16	51.85	41.20	+ 3.16	+ 0.33
	1st 3 feet ..	31.37	28.01	32.03	30.58	—0.79	—0.32
	2nd 3 feet...	28.67	25.20	26.63	26.46	—2.21	—1.15
	1st 6 feet ...	29.85	26.50	29.01	28.38	—1.47	—1.[illegible]
	7th-8th foot	34.08	....	....	35.30	+ 1.22	+ 0.41
	1st 8 feet ..	31.06	....	....	30.40	—0.66	—0.[illegible]
		inches	inches	inches	inches	inches	
Depth of water table		82.0	76.0	....	84.0	—2.0	
Precipitation		....	0.18	0.08	0.71	+ 0.97	

TABLE XV.

Showing Average Soil and Air Temperatures, Temperatures of Mean Dew Point, Averag Reelative Humidity, Average and Total Evaporation and Total Rainfall for the Crop Growing Periods of 1898, 1899 and 1900.

DATES	Average soil tempeertures—depth below surface					Average air temp'tures—height above surface				Mean dew point	Mean per cent. relative humidity	Average daily evaporation	Total evaporation	Rainfall
	1 inch	6 inches	1 foot	2 feet	3 feet	3 inches	2 feet	4 feet	6 feet					
	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	per ct	In.	In.	In.
May 20-31, 1898	61.3	55.4	51.6	46.2	42.9	60.7	61.2	61.5	60.9	48.9	60.9	.20	1.2	1.60
June, 1898	66.9	61.6	58.7	53.8	50.2	63.9	61.6	65.1	64.6	57.1	75.0	.15	4.6	2.19
July, 1898	68.0	65.0	62.7	58.8	55.4	68.4	69.2	70.1	69.8	60.8	71.1	.16	4.9	2.59
August 1-6, 1898	68.6	64.9	62.6	60.1	57.1	68.1	69.3	70.2	69.7	58.1	65.9	.23	1.4	.56
Totals and averages	66.8	62.6	59.8	55.0	54.1	65.7	66.5	67.8	66.7	56.3	67.4	.17	12.9	6.94
May 11-31, 1899	56.9	53.5	49.4	42.8	37.6	59.5	59.8	58.7	57.5	42.4	57.9	.32	6.8	2.91
June, 1899	65.1	62.0	57.4	50.3	46.2	67.6	68.5	67.3	67.5	56.5	71.8	.25	7.6	3.44
July, 1899	70.8	68.3	61.7	58.0	54.2	72.8	71.4	71.6	73.8	61.7	70.9	.20	6.0	2.67
August 1-10, 1899	73.0	68.9	67.4	60.3	57.4	74.5	73.2	70.1	71.9	57.5	67.4	.23	2.3	.28
Totals and averages	65.9	62.9	58.9	52.1	48.0	68.0	68.9	67.6	67.8	54.9	68.0	.25	22.6	9.30
May, 1900	63.1	58.7	53.6	48.5	44.0	66.0	66.6	63.1	64.6	41.7	43.8	.48	14.8	.81
June, 1900	72.2	66.8	61.5	57.3	54.2	72.1	73.7	70.9	72.4	51.4	49.9	.33	9.9	2.11
July, 1900	76.0	69.7	65.1	61.2	59.9	73.8	75.9	71.4	73.2	55.9	50.5	.48	14.9	3.91
August 1-10, 1900	79.4	74.9	70.4	65.5	62.8	80.6	81.2	78.9	80.4	66.9	68.9	.41	4.1	4.24
Totals and averages	71.3	66.0	61.0	56.7	53.8	71.6	72.9	69.5	71.1	51.5	52.2	.43	43.7	11.07

All the above observations except rainfall were taken in the wheat field. Temperature readings were taken at 7 P. M., 1 P. M. and 8 P. M. in 1898. In 1899 and 1900, the readings were taken only twice daily, at 7:30 A. M. and 5:30 P. M.

TABLE XVI.

Showing the Monthly Weather and Crop Records for 1898, 1899 and 1900.

DATE	Temperature			Weather								Depth of water table	Condition of soil	CONDITION OF CROPS
	Mean maximum	Mean minimum	Mean	Prevailing winds	Avg. wind velocity per hour	No. of clear days	No. of partly cloudy days	No. of cloudy days	Average daily sunshine	Possible sunshine	Rainfall			
	Deg. F.	Deg. F.	Deg. F		Miles				hours	hours	inches	inches		
April, 1898 ...	53.7	26.4	40.0	N & S	11.6	12	10	8	....	....	88	71.8	Favorable	Spring- medium early, dry. Wheat sown—slow germination.
May, 1898. ..	65.2	30.0	52.6	N & E	10.0	14	8	9	....	....	4.00	72.5	Favorable	Wheat well stooled—backward in growth. Flax up corn planted.
June, 1898........	76.1	47.6	61.8	N W & SE	10.0	12	9	9	....	....	2.20	41.2	Wet to dry	All grain crops promising; rank in growth.
July, 1898........	80.9	55.3	68.1	SE & NW	8.8	22	7	2	....	....	2.60	72.0	Favorable to dry	Wheat well headed, early grain harvested; a good crop assured.
August, 1898..	80.3	49.8	65.0	N W & SE	8.1	22	8	1	....	....	2.84	85.0	Dry to favorable	Harvest finished; threshing begun; yields large.
September, 1898	72.6	43.2	57.9	S & N W	9.9	21	6	3	....	....	1.23	......	Favorab'e	Killing frost September 9th; corn crop immature; root crops fair.
Totals and averages.....	71.6	43.5	57.6	N W & SE	9.7	103	45	32	....	....	13.72	69.7	Favorab'e	Above the average in production.

April, 1899	54.0	28.0	45.0	N, S & NE	10.9	20	6	4	8.1	13.6	1.30	102.0	Frozen, wet to fav'ble	Spring backward, wheat half sown, too wet to to plow.
May, 1899	65.0	41.0	58.0	NW & SE	11.7	17	6	8	5.9	15.0	4.22	102.3	Favorable but cold	Late and backward in growth; wheat stooling; corn planted.
June, 1899	75.5	53.0	67.0	NW & SW	10.6	20	4	6	8.3	15.8	3.44	91.1	Favorable	A period of rapid growth, promising for all crops.
July, 1899	82.0	54.6	74.5	NW & SW	8.2	27	3	1	9.6	15.5	2.67	85.0	Favorable	Hay heavy; wheat fair; flax, barley and oats good; corn and potatoes promising.
August, 1899	79.7	54.4	71.7	S, SE & NW	10.2	20	10	1	6.4	14.2	3.71	90.1	Dry to favorable	Harvest finished; threshing begun; yields fair to large.
September, 1899	70.5	40.0	59.4	NW & SE	10.7	18	12	0	7.5	2.5	1.24	93.3	Dry	Frost Sept. 12th; soil too dry to plow; corn and potato crops above average.
Totals and averages	70.6	45.0	62.5	NW, SE & SW	10.3	122	41	20	7.6	14.4	16.67	91.0	Favorable to dry	Average crop of wheat; other crops above average in production.
April, 1900	65.0	35.0	50.0	S & N	12.1	24	4	2	8.6	13.6	1.82	102.7	Very mellow, dry	Early spring; all grain sown and most of it up.
May, 1900	76.5	41.6	59.1	S & SE	9.7	27	3	1	10.3	15.0	.81	103.0	Dry	Crops backward, injured by draught.
June, 1900	82.0	50.2	66.1	S, SW, & NW	11.4	19	11	0	8.7	15.8	2.11	101.5	Dry	Grass brown and dead; grain has not stooled; no chance for a crop.
July, 1900	81.7	52.4	67.1	S & N	10.1	14	14	3	8.7	15.5	3.91	97.6	Favorable to dry	Rains benfited late crops; harvest begun; all grain crops very poor.
August, 1900	84.1	61.6	72.9	SE	9.4	21	9	1	5.3	14.2	8.28	72.9	Warm and wet	Grain in shock badly damaged by rains; a remarkable growth of all vegetation.
September, 1900	67.5	45.8	56.6	SE & NW	11.3	13	10	7	4.9	12.6	3.27	69.2	Favorable to wet	More like June than Sept.; excellent fall pasture; wet for plowing; frost, Sept. 16th.
Totals and averages	76.1	47.8	61.9	S, SE & N	10.5	118	51	14	7.7	14.5	20.20	89.5	Very dry to very wet	Grain crops a failure, flax fair, late fodder crops good, fall pasture excellent. The soil has been filled with water, which practically insures a good crop in 1901.

Observation of temperature and weather, except wind velocity, were made under the direction of Prof. E. F. Ladd on the college grounds, but not in the field. The data for wind velocity were obtained from H. W. Grasse, observer, weather bureau, Moorhead, Minn. This station is located three miles southeast of the Experiment Station buildings.

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 49.

SOME POINTS ON FRUIT CULTURE

BY

C. B. WALDRON, B. S.

Any farmer, teacher or student in the state can have this Bulletin mailed to his address, free of charge, upon application.

Fargo, North Dakota, U. S. A.
September, 1901.

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SOME POINTS ON FRUIT CULTURE,

—BY—

C. B. WALDRON, B. S.

The cultivation of fruits in North Dakota, so far as it has been attempted at all, is a thing so recent that nothing in the way of a general report can yet be made.

The most that can be said for the present is something in a general way concerning the varieties and methods of culture that have been found best adapted to regions most closely resembling our own.

Compared with what are known as the fruit belts of the north, such as are found in Michigan, or New York, our own state presents the following well known differences: the winters are colder, the growing season shorter and the rainfall less.

Because of these differences the methods of cultivation as well as the varieties found suited to the places named cannot be successfully used here.

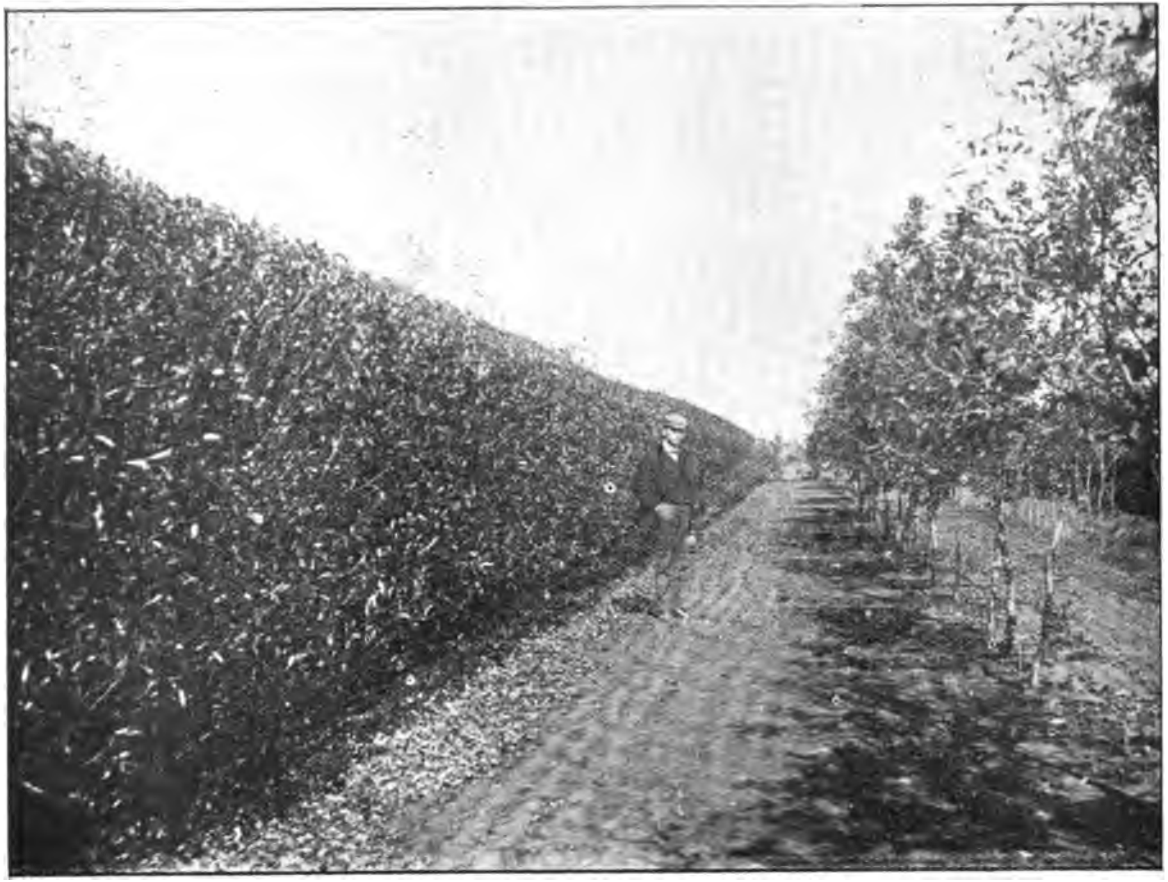
The matter of varieties will be taken up later, but first a consideration of general principles, particularly as applied to this region will be in order.

It must be evident to the most casual observer that trees or shrubs of any kind will not endure the neglect here that is so often their lot in more favored regions. This is not equivalent to saying that neglected plants are often profitable anywhere nor that labor applied to fruit plantations here is unprofitable. It means simply that with us but little opportunity for a compromise with nature exists. One must be prepared to do his part in adapting the natural conditions to the needs of the plant. Such work lies right at one's hand. It is definite and immediate in its results and to neglect it in the vague hope that some mysterious agency will adapt the plants now existing to new conditions, no matter how trying, is but exchanging substance for shadow.

At the outset, aside from the matter of mere cold, trees and shrubs, particularly those grown for their fruit, are not prairie plants. They require something like forest conditions, that is a deep, moist, mellow soil and more or less protection usually afforded by other trees and shrubs.

The means of obtaining such protection has been treated in former bulletins Nos. 25 and 41.

While climate definitely and specifically determines the range within which certain fruits can be grown, yet once within that pos-



SHELTER HEDGE OF GOLDEN RUSSIAN WILLOW—5 Years Old, Station Grounds.

sible range, success or failure depends very largely upon the condition of the soil, in fact to a much greater extent than is generally thought possible. Varieties once thought to be tender in the middle west are now found to be hardy enough if the proper method of tillage is observed. Trees grown in dry shallow soil winterkill—but not necessarily because of the cold. In fact the most trying winters upon trees and shrubs, at this station, have been the mildest and the ability of the plants to endure such winters rests largely upon the treatment given the previous season.

The cause of the winter-killing in mild winters is due to a drying up of the twigs, so that in the spring there is not enough moisture left in the plant to enable it to renew the life processes. Some plants resist this evaporation better than others and are valuable on that account, while on the other hand some species that will survive the most intense cold have been observed to kill badly in mild but drying winters, the branches being so light and dry in the spring as to fairly rattle when handled.

The protection afforded woody plants in winter is valuable chiefly in preventing evaporation, as the degree of cold could not be largely affected.

Aside from protecting the plant, what can be done to lessen the drying up of the twigs? Since there is such a fatal tendency for woody plants to give up their moisture during the winter months, one would naturally infer that such treatment as would enable plants to begin the period of rest with the maximum quantity of moisture would be the best. This is emphatically true. Trees and shrubs that are neglected during the latter part of the season so that the ground becomes hard and dry, ripen their wood prematurely, and unless fall rains are abundant, the drying process sets in before winter begins, leaving the plant in poor shape to endure further drying. Moreover the roots which should have had the encouragement of a loose moist soil until the end of the season, that a large number of new and active roots might develop, have been practically at a standstill. The root-hairs which live but a short time and need constantly to be renewed are not in existence and the young roots themselves become dry and inactive. A plant beginning the winter in this condition can make but a feeble start in the spring at the best and not many experiences of the same kind are required to make the result fatal. Compare the big firm buds on the twig of a tree that has had the advantage of a deep moist soil and good cultivation to the end of the season with the thin soft buds found on a tree growing in hard dry soil and that has, on that account, ripened its wood prematurely. These buds are next season's branches and contain the next crop of fruit and their vigor or weakness is a matter of greatest importance.

Fruit buds of many plants do not form till toward the close of the growing season and then not at all if the cultivation be lacking or bad.

In general, then, that fruit plants may thrive, set fruit buds and endure the winters, give them deep soil naturally mellow and moist and cultivate it from the beginning till the end of the season. There is occasionally something said about stopping cultivation in August, so that the plants may have opportunity to ripen up their wood for winter. There may be regions where this is good advice, but our experience and observation have led us to just the opposite conclusion and practice for the northwest. When winter once begins to settle down upon the land in North Dakota, even the trees have sense enough to detect it, and the suddenness and completeness with which they close up their summer affairs and get into winter attire suggests that they need no aid from us in the matter. Indeed some of the plants that defer this change the longest, like the buffalo berry and lilac, are among the hardiest we have.

Another matter of recognized importance among successful horticulturists is that of providing some cover for the soil in winter, to prevent root killing. In summer the best cover for soil, all things considered, is a shallow layer of the soil itself, kept loose and mellow by constant cultivation. As winter comes on this becomes compact and frozen affording no further protection. Unless covered with snow the ground soon becomes very dry and cracks open allowing the roots to dry out and subjecting them also to an unusual and unnecessary degree of cold. By covering the ground with a light layer of straw or similar material about the first of November, this condition is avoided. This covering prevents the escape of moisture, as the drying winds cannot come in contact with the soil and also the escape of heat, thus delaying freezing for a considerable time, and shortening the period in which the plant is losing moisture, without means of supplying the loss. Theoretically, then, the application of a mulch would seem to be an advantage and in actual practice it has been found to be of the greatest importance, saving whole plantations in regions where unprotected trees were practically all killed.

CHOICE OF LOCATION.

Since the atmospheric conditions are largely influenced by the contour of a country, the selection of a site is an important matter. In level stretches like the Red River Valley, there is little oppor-

SHELTER BELT OF NORWAY SPRUCE. Station Grounds.

tunity for choice, but in rolling sections one may discriminate. By observing the spots that the native trees and shrubbery select, one may come to a very easy and correct solution of this point. Even in the arid portion of the state thrifty shrubs will be found growing toward the bottom of the north side of the hills and buttes. It is not well to plant too low down on the hillsides for the cold air settles there, increasing the danger from late frosts. Too near the top of the slope the soil is often dry and thin and the exposure needlessly great.

A little intelligent study of the land will enable one to select a site having some protection, good atmospheric drainage and the proper soil.

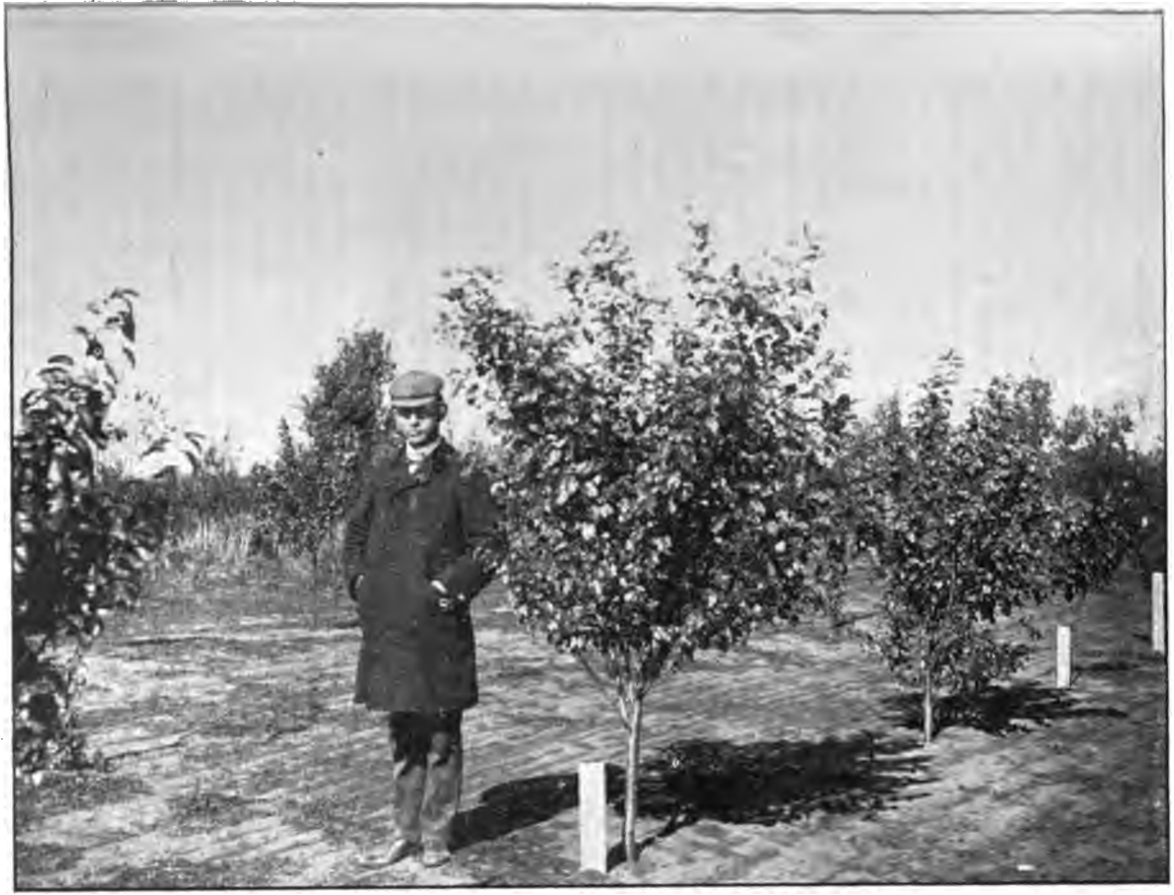
South slopes are too dry, the sun is too hot there and the drying process altogether too active. They should be avoided.

So much, then, for the general directions to be observed in tree or fruit culture. Because such directions are simple and easy to follow does not mean that they are unimportant. The truth is that if we do not observe them there is really no need of following other very obvious rules—such as planting with the roots downward, for in the neglecting of the directions given above plants would do quite as well with either end up.

PLUMS.

Cultivated plums extend through several species, only one of which, the American plum (Prunus Americana) can be grown at present with any success in the state. Belonging to this species are a large number of varieties, some 150 in all, that have been offered for sale at one time or another. Probably not over one-third of these have any special merit, while a half dozen of the best varieties would supply the needs of the average man. So far as tried here they are all hardy, though some ripen late, and most of them are vigorous and productive and of course profitable. The quality of the average of these is about equal to that of the best of the native plums and their larger size and firmer flesh makes them the more desirable for both market and cullinary purposes.

To one accustomed to the domestic plums of the warmer latitudes, they are not always entirely acceptable but for certain uses, particularly of making jelly or marmalade, they are much superior. Indeed there are many persons of cultivated taste who prefer them for all purposes. The soft flesh of most of the varieties renders them unfit for shipping long distances, but if carefully handled they will keep long enough for local market purposes. Whatever their faults or virtues, we can grow no other and with the rapid improvement that has taken place within the last twenty



TYPICAL PLUM TREE—5 Years from Bud. Station Grounds.

years it is safe to predict that within a very few years we will not wish to grow any other. All things considered they are the easiest and most profitable fruit to grow in North Dakota and the man who neglects to set out at least a few trees is denying himself a considerable blessing.

Trees planted at the Station grounds ten years ago have borne heavily for the last five years and the difficulty we experience in getting even a fair share of the fruit for ourselves shows that it is highly appreciated by the public.

CULTIVATION.

The plum likes a deep moist soil of heavy quality. It would be difficult to find a spot in the Red River Valley where they would not succeed and for the outlying portions of the state, a cool north slope with suitable soil should be selected.

Before planting the trees the soil should be put into shape to admit of ease in cultivation. If it is not already in a good tillable state, a cultivated crop like beets or potatoes should be grown for one season before the trees are planted. The more thoroughly this previous crop is cultivated, the more sure the trees will be to make a good growth. In northern latitudes trees should be planted in the spring and as early as the condition of the soil will permit.

When the trees ordered come from a region further south than the one in which they are to be planted, the order should be sent early enough so that they may be shipped before the buds start. If the trees arrive before planting time, they may be covered with soil or wet straw for a few days. Ordinarily the trees will be two years old from the bud, that is a two year old top on a three year old root.

About the most satisfactory way of planting is in rows sixteen to twenty feet apart, the trees to be from eight to ten feet apart in the row. This admits of easy cultivation between the rows with any two horse implement.

Some of the most successful growers recommend planting four or even six inches deeper than they stood in the nursery. There is no doubt an advantage in this practice in the matter of moisture and of protection from freezing.

The necessity of care in planting need hardly be insisted upon, its importance is so generally understood. The trees should not be exposed to the sun and wind so as to become dry. They should be opened up as soon as they are received from the nursery and the roots kept covered with moist earth or straw till the last minute before planting. The earth at the bottom of the holes is not usually adapted to the starting of the young trees and a generous layer of loose surface soil should be filled in. The soil used in filling around the roots should be of the same character and if not naturally very mellow, decayed leaves, sods or other vegetable matter may be worked in. This will prevent the drying out and baking of the soil directly about the tree. With moist soil of this character worked around the roots and well firmed, there will be little possibility of failure.

If some cultivated crop like beans or beets, that does not require too much moisture be allowed to grow between the rows of trees, they will do quite as well as if growing alone, while there will be a greater incentive to keep them cultivated.

With such soil as is commonly found in the state, the plum will need no manuring at first and in fact is apt to make too great a growth of wood when manure is applied.

An application of wood ashes is recommended by most fruit growers on the ground that it helps to mature and ripen the wood.

If the soil is not of the first quality, a surface application of well rotted manure may be needed after a few years, but with such soil as we have at the Station, there is no need for even this much fertilizer.

The matter of late cultivation may need to be modified to a certain extent in seasons of unusually abundant rainfall.

If the ground is free from bad weeds in such seasons as that of 1900 or 1901, it may be well to stop cultivation after the middle of July, particularly if the trees are growing pretty fast. In any season the late cultivation should not be deep, the object being to retain the moisture and not to stimulate the growth.

MULCHING FOR WINTER.

The application of two inches of coarse manure or straw, covering the entire surface, or at least as far as the roots extend, while not an absolute necessity under all circumstances, is no doubt a good practice. It should be applied before the ground begins to freeze, for reasons already explained, as well as for the fact that the delay in freezing of the soil, caused by mulching, gives the plants a longer time in which to prepare for winter.

PRUNING.

The plum requires but little pruning and its naturally wayward habit of growth should not tempt the grower to use the knife too freely. To remove the suckers and water sprouts, pinch back the too rapidly growing shoots, or cut out a too unruly branch is about all that should be attempted. The trees should be headed low as shown in the cut and after that allowed to take about their natural shape. Such pruning as is required may be done at any time of the year.

THINNING THE FRUIT.

The standing fault of the American plums is that they bear too freely. This habit exhausts the tree, renders the fruit small and tends to make the trees bear only alternative years. Good judgment ought to enable a man to see when a tree has set too much fruit. If, to the inexperienced grower, the quantity looks to be about right just as the fruit is beginning to grow, it is safe to say that half of it should be picked off. The quantity will be about as great, the quality much better, while the tree will be ready to endure the winter well and bear the following year.

VARIETIES.

For general cultivation the following varieties will be very sure to succeed: DeSota, Forest Garden, Weaver, Cheney, Wolf, Rolling Stone, Wyant. These are the varieties recommended by the Minnesota Horticultural Society and their value has been demonstrated by repeated trials under many conditions.

Those recommended as promising varieties for trial are Ocheeda, New Ulm, Stoddard, Surprise, Mankato, Aitkin and Owatonna.

A pretty accurate description of most of the varieties mentioned can be found in the catalogues of the leading nurserymen. It is to be hoped that the readers of this will be familiar enough with some of the varieties within a few years to need no description.

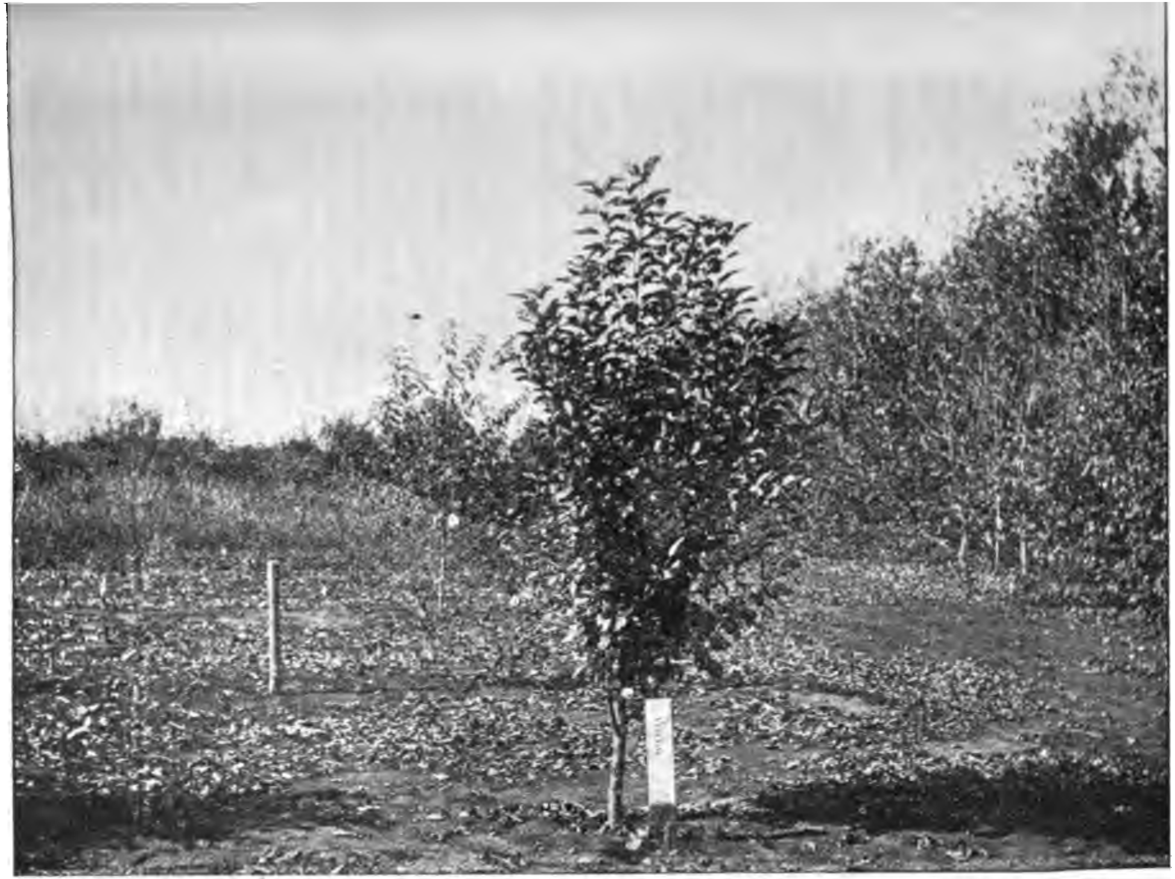
APPLES.

The apple can hardly be recommended for extensive cultivation in North Dakota. The climate is not necessarily too severe for all varieties, but the situations, particularly in the Red River Valley and similar flat stretches, would be considered pretty trying in much milder latitudes. As the country becomes more settled and the protection of windbreaks and groves is afforded there is no doubt but some success with apples can be attained.

Any good farming land with good natural drainage is capable of growing apples if the other conditions are favorable. For reasons already given the northeast slope has the advantage.

To facilitate cultivation and prevent sun scald, plant the trees in north and south rows about 28 feet apart, the trees being 12 feet apart.

Low headed trees planted in this manner protect each other



GOOD TYPE OF APPLE TREE—5 Years from Graft, Transplanted at 2 Years. Station Grounds.

from the winds and from the sun which frequently scalds the bark on the trunk causing the death of the trees. Until the trees are large enough to furnish this protection, corn stalks tied close around the trunk will prevent any injury from that cause.

The best trees for planting are two years old, with the branches beginning about two feet from the ground. They should be allowed to grow in about their natural form. If the head grows too compact, remove some of the interior branches. At the time of planting the tree is of course cut back on all sides. This gives rise to a cluster of branches near the end of the limbs cut off. While they are still small enough some of them should be removed to give the head a free open growth.

The trees should be set considerably deeper than they grew in the nursery. After covering the roots well with fine soil, working it into all the open spaces and firming it, it is a good practice to fill to within an inch of the top with partially rotted sods or similar material, covering this over with a thin layer of earth. This maintains a more even temperature about the roots than ordinary soil would and retards freezing in the fall as well as baking and drying of the soil in summer.

ENEMIES OF THE APPLE.

Apple culture has not been so extensive as to develop the codlin moth, apple scab and other well known pests of apple countries.

There is one serious drawback, however, the blight, that has been more fatal than the cold winters. This is a specific disease due to the presence in the sap of a minute organism that is usually introduced into the plant through the blossoms by the insects that visit them. A tree may appear to be immune until the bearing season when blighting begins, which often results in the death of the tree. The disease may also be introduced through the opening buds, as very young trees at this station have been known to blight to the ground the second year after planting.

Some localities seem to be particularly subject to blight and some varieties blight badly while others never do. It is unfortunate that many of the hardiest varieties are very susceptible to blight. In some parts of the state is has never been noticed, so apple culture, so far, is not impossible from that cause.

The only remedy is to remove the blighted branches as they appear, cutting them off at a point below where the bark is dark and shriveled. Aside from the withered bark the evidence of the blight is seen in the dead leaves of a particular branch. It usually appears first in June.

VARIETIES.

The Minnesota Horticultural Society recommends the following: Of the first degree of hardiness: Duchess, Hibernal, Peterson's Charlemoff, Patten's Greening.

Of the second degree of hardiness: Wealthy, Longfield, Tetofsky, Melinda. Promising varieties for trial: Okebena, Peerless, Repka, Melenka, Anisim, Yellow Sweet, Kaump, Gilbert, Brett, Christmas, Blushed Calville, White Pigeon.

CRABS AND HYBRIDS.

For general cultivation, Virginia, Martha, Whitney, Early Strawberry, Minnesota Sweet Russet, Gideon's No. 6, Briar Sweet. Promising varieties for trial, Dartt, Pride of Minneapolis, Crampton's No. 3, Lyman's Prolific, Faribault.

CURRANTS AND GOOSEBERRIES.

These fruits are natives of northern latitudes and the varieties tested at this Station have been found hardy. Requiring less attention than most other fruits, their reliability and fruitfulness make them about the most profitable of cultivated fruits.

While it is true that any one can grow currants, still there is a wrong way even in that. These fruits do best only in a heavy moist soil in a cool location, and one is not likely to hurt his prospects for fruit by having the soil too rich. Set them four by eight feet apart and give them the same clean tillage that all fruits should have. They require no protection in the winter, but a good covering of mulch is an advantage in dry open winters. If the ground is very free from grass and weeds this may be left on for a time, cultivation meanwhile being omitted.

Success with currants and gooseberries depends largely on pruning, the common error being to allow the plants to become too thick. About six or eight well grown canes will yield more and better fruit than a large number, and the picking and cultivation will also be easier. Canes should be removed when four years old and enough new ones allowed to take their place, but not more. With eight canes to a plant, removing two old ones and allowing two new ones to grow each year keeps the number constant.

In this latitude the canes are not likely to grow too tall, but at any rate they should be kept to a height not exceeding three feet and if they show a straggling habit should be pruned to make them trim and upright.

VARIETIES.

The following varieties have all done well at this Station and may be depended upon for general cultivation:

Red Dutch, London Market, Victoria, North Star and Stewart. Of gooseberries the leading sorts for the northwest are Houthton, Downing, Champion and Red Jacket.

RASPBERRIES.

In most parts of the country the raspberry is cultivated far more extensively than the currant and the fruit seems to find wider·favor with the public. It is not so hardy as the currant and on that account requires more attention. It likes a deep moist loamy soil with good natural drainage and thrives best when afforded some protection from the sun and wind.

While the plum and the apple trees are yet small, a row of raspberries may be planted between each two rows of trees or a young grove with the rows of trees twelve feet or more apart can be made profitable by the protection it affords the raspberries.

The raspberry is not difficult of cultivation if all the work be done at the proper time, but on the other hand there is nothing much more troublesome and less profitable than a neglected raspberry thicket.

The red raspberry belongs to a different species than the black and its different habit of growth demands for it a somewhat different culture. It propagates itself by suckers, and in making the bed, these are set about five inches deep and in rows five feet apart east and west and six feet apart north and south, except of course as they are set among trees when the distance apart will be governed by them.

The black raspberry should be set the same distance apart as the red, but the tips by which it propagates itself should be set only one inch deep at first and in the bottom of a shallow furrow, so that he soil may be filled in to the depth of four inches later on. The object in setting the plants so far apart is to make cultivation easier and with the larger growing black varieties, even a greater distance might be found more convenient.

The raspberries at the Station set four feet apart demand too much hand labor that could be dispensed with if they could be cultivated in both directions. With the red raspberry especially, the worst weed in the patch will be found to be the thing itself and there is no easier way to destroy the numerous suckers than with a cultivator having square sharp teeth that cuts them off below ground.

The raspberry will do nothing on hard dry soil. Frequent cultivation is a necessity, especially where the rainfall is light, and the planting should be done in such a way as to make this process as easy as possible.

At the time the plants are set the canes should be cut back nearly to the ground so that a number of new shoots will appear. During the first season any kind of a cultivated crop may be grown on the land set to berries. Put your plum or apple trees out here if there is no better place.

If the plants fail to make a very vigorous growth the first season and the result in the fall is but two or three weak canes to the hill, it is our custom to cut them back to the ground and cover the hill with coarse manure. The young canes will start out all the more vigorous the following spring, and the temptation to let the first year's canes bear fruit is entirely removed.

The second year, then, tne berry patch will consist simply of a number of young canes starting up from the root of each plant. When they are about a foot high all but five or six should be removed and the number should be kept at that for the balance of the season.

When the canes of the black varieties are a little higher, say 18 inches, the tips should be pinched off to induce a stocky branching growth. Such canes stand up better and yield more heavily than will long slender canes grown to their full length.

The same process applied to the red varieties induces too great a growth of suckers, at least after the first year, so the better practice with them is to let the new canes grow to their full length, cutting them back to two and one-half or three feet in the fall or following spring.

Now at the end of the second summer, our berry patch consists of plants of about five young strong canes each, all ready to bear the following season. If any bearing canes have been allowed to remain, they should be removed, and preparations made for winter.

WINTER PROTECTION.

No one who has had experience ever attempts, or at least expects to grow raspberries in the northwest without winter protection. The cost of protecting the plants is so slight and the disastrous consequences attending the opposite course are so disastrous that there is no room left for argument. Our plan is simply to bend all plants over to the north, covering them with coarse manure. To prevent breaking of the canes, a forkful of the manure is laid on the ground at the base of the plant and the plant bent over it, or in the black varieties, a better way is to dig away the dirt on the north side and bend them over in the root, one man holding them over with a fork while the other throws on the covering material from a wagon.

This process must be done early, before freezing weather sets in, or the canes will break in bending.

In the spring take off the cover, but not too early, say, about corn planting time. If the cultivation has been thorough the previous season the mulch may be left about the plants to retain the moisture and the cultivation be confined to the middle of the row. Later as the suckers start it will be an advantage to cultivate close to the hill.

With no mishap the plantation should now bear nearly a full crop. While the canes that have been lifted in the spring are blossoming and preparing for fruit, the same number of new canes are allowed to grow for the next season's crop. They are to be treated exactly as the young canes were the year before. After the bearing canes have produced their crop of fruit, they are cut out and destroyed. This is not a matter of policy as most of you know, for their career is ended.

A bed well cared for will last about eight years when another should be started.

VARIETIES.

Of the red raspberries, the Turner, Marlborough, Cuthbert and Loudon have all done about equally well in the northwest, all things considered, while the black and purple varieties will succeed best through such varieties as the Ohio Nemaha, Gregg and Columbian.

STRAWBERRIES.

Of all the small fruits, the strawberry undoubtedly takes first place and it is a cause of great regret that its cultivation in this state has not been attended with greater success.

The most serious drawback in our ten years of experience in North Dakota with this fruit is the strong, drying wind that prevails for two or three days, sometimes between the blossoming and ripening of the fruit, greatly reducing the yield. For this reason we have not pushed the culture of this fruit, but now that our windbreaks have grown to a fair size, we are attempting to grow it on a somewhat larger scale with hope of some success.

If a severe drying wind comes at the blossoming period, the combined effect of the wind and dust is to dry the blossoms to a point beyond any possibility of fertilization.

In a rolling country this evil can be mitigated somewhat by selecting the less exposed places, but on level land shelter belts of

Trial Bed of Strawberries—Five Months from Setting. Station Grounds.

Strawberry Bed—After First Crop. Station Grounds.

trees will be necessary. The winds that do the most damage are from the south and west.

The strawberry does best also in regions where the rainfall is heavier than in North Dakota, but by frequent and thorough tillage we can hold the moisture that does fall, which will usually answer very well if the soil be naturally retentive of moisture.

If the soil be allowed to dry out, particularly just before the ripening of the fruit, the few seedy berries that one would obtain would be apt to dispel any enthusiasm that he started out with. When strawberries do succeed they are very productive and a very small patch on a deep loamy soil well protected and cared for will supply the needs of any family.

Where water can be supplied from a well or reservoir, of course one has a better chance of success. In this case the water should be let into furrows between the rows, and after the soil is sufficiently dry again, it should be cultivated, for a soil continually wet and soggy is quite as fatal to the strawberry as a very dry one.

To make up for the dêficient rainfall, plants shouuld be set rather further apart than is ordinarily recommended, that the cultivation may be more thorough. Two by four feet is about the right distance for all purposes.

Set the plants in the spring and set them right, with roots well spread out and extending downward and the soil packed firmly about them. A spade is the implement we use for this purpose. With it a wedge shaped opening can be made simply by pushing it into the ground the length of the blade and thrusting it forward a little. After it is withdrawn the roots of the plant spread out like a fan, are inserted when another plunge and thrust with the spade just back of the plant closes up the opening. Fill the opening last made with water and the operation is complete.

The plants should not bear the first season. Keep them constantly cultivated and allow three or four runners to grow from each plant, confining them to the row so as not to interfere with cultivation.

Before the ground begins freezing, cover the berry patch all over with two inches of coarse mulch, straw is good, and leave it there until spring. If the soil be in prime condition the straw may be simply removed from the plants and left between the rows till after fruiting to serve as a mulch, but ordinarily the better plan is to rake it off and begin cultivating.

The biggest and best crop of fruit should come the first year after planting.

It is the custom of some growers to plow up the bed after the first year, but most of them give it a thorough renovating by cultivating deeply, removing the plants where they are too thick and working in a top dressing of finely rotted manure. All this is done in the late summer and fall and is quite a necessary undertaking for one that expects much fruit the second season. In fall the bed is covered as before.

After the second crop of fruit the bed is plowed up. In making the new bed, it is understood of course, that only the young plants are to be used.

VARIETIES.

The leading pistillate varieties for the northwest are the Crescent, Warfield and Haverland. When these are used alternate rows of some stanimate variety must be planted for fertilizing them. The sorts most often employed for this purpose are the Bederwood, Enhance, Lovett, Mary and Splendid.

WINDBREAK AND HEDGE OF SOFT MAPLE. Station Grounds

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 50.

FLAX WILT AND FLAX SICK SOIL.

By H. L. BOLLEY.

Any farmer, teacher or student in the state may have this Bulletin mailed to his address, free of charge, upon application.

FARGO, NORTH DAKOTA, U. S. A.
December 1901.

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FLAX WILT AND FLAX SICK SOIL.

By H. L. BOLLEY.

Group of young flax plants just beginning to wilt.

The cultivation of flax, in every country in which it has been grown extensively, has either been short lived or it has been necessary to introduce a long series of different crops between the flax crops. The best methods in Scotland, Ireland, Belgium, Germany and Russia make it quite plain that the principle of crop rotation has become a cardinal one in these countries where the culture of flax for fiber purposes is given so much attention. The late Dr. Otto Lugger of the Minnesota Experiment Station, who was thoroughly conversant with German and Belgian methods, published in his "Treatise on Flax Culture" * several series of rotations which Belgian farmers have, through long experience, found conducive to proper flax growth. A consideration of these shows that a large variety of crops is interposed in all rotations and that the time between flax crops is quite uniformly seven to eleven years. Flax is an important crop there, and it is evident that the energetic Belgians would grow it more often, were it possible to do so profitably. But Dr. Lugger says: "It is well known in Europe that flax is a plant unkind to its own offspring."** that is to say, flax cannot succeed flax upon the same soil and remain strong. Mr. James B. Taney, U. S. Consul at Belfast, Ireland, reporting upon the flax crops says: "The idea has prevailed among many that Ireland is flaxed out." ***

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* Bulletin No. 13, Minnesota Experiment Station, p. 26.
** Bulletin No. 13, Minnesota Experiment Station, p. 23.
*** U. S. Consular Report for January, 1895, pp. 51-57.

In America, in each new locality in which flax has been introduced, it has been a short lived crop; at first making heavy growths upon the virgin soil, but later gradually failing. This is so characteristically true that the crop is generally known as a new land crop. In the west, Iowa was once the banner state for flax, then Minnesota, now North Dakota. In many localities of Iowa and farther east, the crop has been abandoned as no longer a profitable one; and it is a common expression among farmers that the soil is "*flax sick.*" Others assert that flax quickly exhausts the land. I find that this prejudice against the crop is especially strong among European and English farmers who have located in the northwest. It has generally been considered a hard crop on land, quickly reducing its value not only for flax but also for wheat and other crops. In North Dakota, the opinion of the farming public has changed rapidly within the past few years, so that most farmers now state that wheat and other crops may follow flax to advantage, but that flax after flax becomes continually less productive. In short, it may be asserted that close or continuous cropping with flax never has been profitable in any country, no matter what the fertility; and there is abundant evidence that Minnesota and Dakota lands are not to be an exception. The farmers are beginning to report many areas of "flax sick" soil, upon which the flax either fails to come up or gradually dies off during the season.

THEORIES AS TO THE CAUSE OF THE TROUBLE: There have been several theories as to the cause of this flax trouble: (1) that it is due to soil depletion; (2) that it is because flax is "unkind" to flax, leaving some substance in the soil which is detrimental to the health of following flax plants; (3) that it may be due to an infectious disease.

The work upon which this bulletin is based indicates that the first two propositions are untenable and, I think, demonstrates that the third is the correct theory.

PREVIOUS WORK UPON THE DISEASE: Previous to the experiments and observations here recorded, and aside from the efforts of European farmers to find a proper series of crop rotation, there seems to have been but few definite efforts to determine the causative agent or to arrive at a preventive or a remedy. Of these attempts, the experiments of Professor Lugger* of the Minnesota Experiment Station, conducted during the summer of 1890, constitute the only work of importance done in this country.

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* **Minnesota Experiment Station Bulletin No. 13, pp. 21-25.**

Dr. Lugger planned three experiments: (1) *"Series of Experiments to Observe the Effects of Fertilizers upon Land Exhausted by Flax."* He used as fertilizers, lime, acid phosphate, muriate of potash, salt, nitrate of soda, super-phosphates, land-plaster and ground oil-cake. After considering the results, his conclusion was: "Exhaustion of the soil by previous flax crops cannot be the cause of the disease, as all of the materials formerly removed by the plants (flax) had been added again to the soil in the most soluble state." (2) *"Series of Experiments to Observe the Effects of Fungicides on Plants Grown upon Infested Soils."* Professor Lugger pulverized the following fungicides and sowed them as a dry mixture with the flax; hypo-sulphate of sodium, air-slacked lime, sulphide of sodium, flowers of sulphur, sulphate of copper, sulphate of iron and corrosive sublimate. The conclusion from these experiments was: "It is not a specific vegetable disease which affects the plants because one or other of the fungicides would have shown the effects of its application." "Every single plant succumbed." He also says: "Large numbers of dissections were made, and thin sections, stained in various ways, were studied. But a specific organism causing the death of the plants could not be found." "A cure for the disease does not seem possible." The fact that Dr. Lugger used infested soil upon which to make the experiments and his failure to find any parasitic growth in the tissues of the plants examined caused him, I think, to draw the wrong conclusions. Similar experiments and observations with us lead to different conclusions.

(3) *"Series of Experiments to Show That the Old Straw of Flax Is the Cause of the Trouble."* In these experiments Dr. Lugger made effective soil infections by applying: "dry healthy chaff of flax," an extract from "healthy flax chaff in cold water," an extract from "healthy flax chaff in boiling water," an extract from "healthy green flax in boiling water," an extract from "diseased fresh flax in boiling water," an "extract from diseased fresh flax in cold water," and "green straw of healthy flax plants cut into small pieces." From this series, this conclusion was drawn: "We have not to deal with a disease, but the straw of flax itself is the cause of the trouble." My experiments show that diseased flax straw does convey the disease but healthy flax straw cannot. It seems probable that the flax straw, chaff, etc., used by Dr. Lugger was not healthy. Indeed he probably used disease bearing seed, and the results were also vitiated for that reason. Under such circumstances, the solutions used, even though themselves free from the disease, would bring about a

rapid propagation of the fungus which is now known to be the essential cause. Professor Snyder * has shown quite conclusively that a normal flax crop does not make a heavy draft upon the soil. He says: "Flax does not remove an excessive amount of fertility from the soil. An average yield of fifteen bushels of flax per acre will remove less fertility from the soil than one hundred and fifty bushels of potatoes, forty-five bushels of corn or thirty bushels of wheat." The following summary, taken from one of his tables compiled to show the approximate amounts of the chief plant foods which are taken from the soil by different farm crops, would seem to bear out his conclusion. There are also biological proofs that the soil upon which the disease is heavy has not lost its fertility. **

TABLE SHOWING COMPARATIVE DRAFT UPON SOILS BY DIFFERENT CROPS.

CROP.	Nitrogen lbs.	Phosphoric Acid lbs.	Potash lbs.	Lime lbs.	Silicon lbs.	Ash lbs.
Wheat................20 bu.	35	20	35	8	116	210
Barley................40 bu.	40	20	38	9	72	216
Oats..................50 bu.	50	18	45	11	75	205
Corn..................65 bu.	75	20	60	12	90	200
Peas .... 30 bu.	..	25	60	75	10	240
Mangels.............10 tons	75	35	150	30	10	350
Potatoes ....150 bu.	40	26	75	25	4	125
Flax..................15 bu.	54	18	27	16	3.5	87

THE DISEASE IN EUROPE: As yet we have no definite proof that the disease of the soil and flax plant which we have under consideration is the one which has caused the apparent soil trouble in Belgium and other European flax districts. The general conditions, however, which compel the farmers there to interpose a long series of rotation crops between flax growths seem similar to the conditions which are found here in the northwest. In a report by Mr. Paul Nypels† to Royal Botanical Society of Belgium, a number of flax diseases are described, among which is one the author calls "*La brulure du lin.*" In the Netherlands it is called

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* Bulletin No. 47, Minnesota Experiment Station p. 5.

** See this bulletin p. 34.

†Compte-rendu de la seance du 5 decembre 1897 de la Societe royale de botanique de Belgique. Bulletin, tome XXXVI, deuxieme partie, pp. 183-275.

"*Vlasbrand.*" Nypels quotes from and summarizes the investigations of L. Boekema. ** From descriptions there given, I find certain statements concerning the soil conditions and the disease which are so similar to those found here that I have no doubt that "Vlasbrand" of Belgium is identical with the disease which causes flax-sick soil in North Dakota. The author quoted says: "The disease is very prevalent in Holland, Belgium and in North France. It exists also in Ireland and in Germany; but in Russia it does not appear or is hardly known." Of the damage done by the disease, he says: "Sometimes the disease is so destructive that the product is absolutely nothing." After making many experiments, which quite conclusively point to the conclusion that the disease is due to some parasite, Broekema concludes that the disease appears to be caused by a parasitic organism and thinks that the organism in question is probably of the nature of a bacterium. As in the case of Professor Lugger, a definite cause for the disease was not found.

IMPORTANCE OF THE QUESTION TO FARMERS OF THE NORTHWEST: As there are thousands of acres of new soil in the northwest which are free from this soil disease, one may readily understand the importance of ascertaining the exact or first cause that we may learn its habits and some method of preventing its spread and ravages. If, by careful farming, we can perpetuate the flax crop in this state, it means millions in wealth. The number of crops which can be grown in this northern latitude are limited; and farmers can ill afford, through careless methods, to strike flax from that list within the next few years. Professor Shepperd, using ordinary flax seed, not more generally infected with the disease than the average market sample, through six years of continuous cropping has placed a plot of the most fertile Red River soil in such a diseased condition that not a plant of flax can exist upon it longer than three weeks from the time of sowing. * The experiments made during 1900 and 1901 give much promise that the disease can, in large measure, be controlled through intelligent methods of prevention and culture. They also indicate that, if the attention of farmers generally is not quickly given to this matter, it will soon be too late, as the disease has means open to it for general distribution, which will be beyond control when many areas in the state once become thoroughly infected. It is

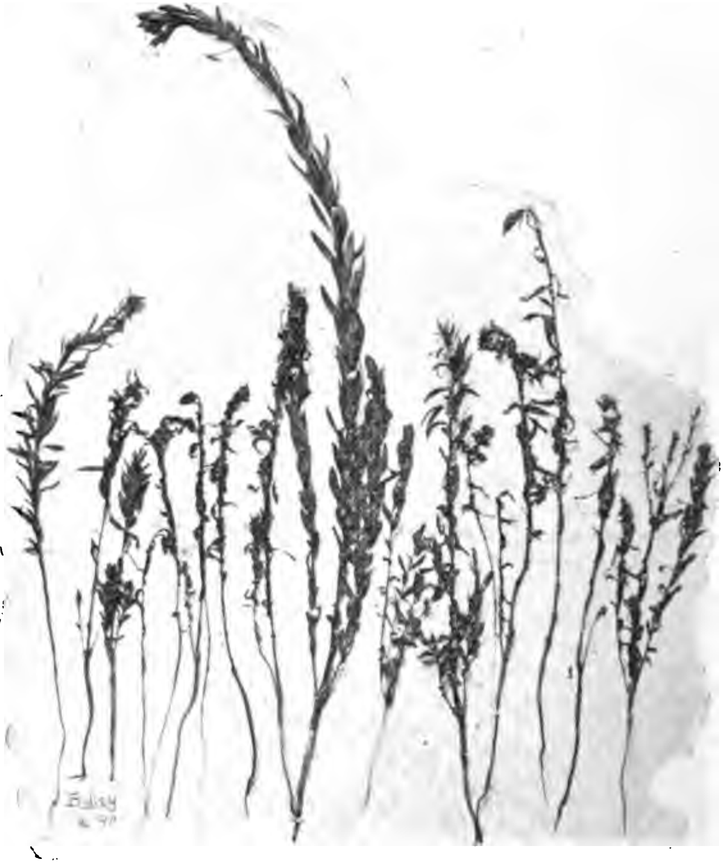
---

** Eenige Waarnemingen en denkbeelden over den vlasbrand. Landbouwkundig Tijdschrit, 1893, bl. 59 en 105.

* This plot of ground is known in the College Records as plot No. 30. One of the reasons for keeping it in continuous flax cropping was for the purpose of ascertaining what effects such methods would have in developing flax diseases.

a soil disease and can live in the humus from year to year; thus there will be many ways in which it may spread from field to field. Let every one experiment some and unite to stamp out the disease. We cannot hope that the disease may be less destructive in this region than elsewhere; for my experiments show that it is a lover of rich and alkaline soils.

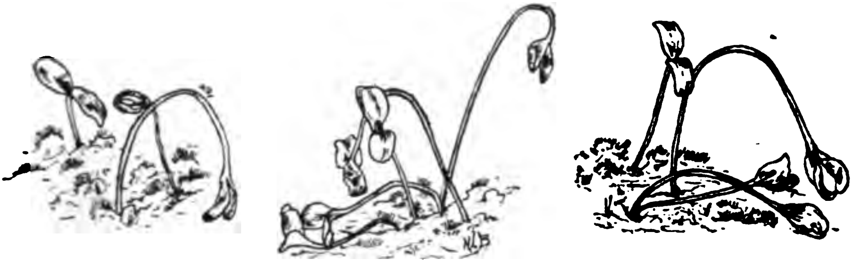
DISTRIBUTION OF THE DISEASE IN THE STATE: I have seen the disease in the field at Fargo, Harvey, Larimore, Hunter, Val-



Photograph showing the effects of the wilt disease upon flax plants of various ages.

ley City and Casselton; I have received specimens of the diseased plants from Cando, Park River, Devils Lake, Grand Forks, Hillsboro, Sheldon, LaMoure and Barton; I have also found the spores of the parasite in numerous samples of seed received from other points in the state, and from several different counties in Minnesota. It is very probable therefore that many fields in different parts of the state have already been infected.

THE APPEARANCE AND CHARACTERISTICS OF THE DISEASE AS SEEN IN THE FIELD: The plants are attacked at all ages and die early or late in the stage of growth according to the time and intensity of the attack. If the soil is much infected, that is to say "flax sick," most of the plants are killed before they get through the surface of the ground. Such areas appear in a field of flax as centers of disease, which enlarge throughout the summer as new plants sicken, wilt, and die down around the margins of the spots, finally giving the whole field a spotted appearance. Young plants, two to five inches in height, wilt suddenly, dry up and soon decay if the weather becomes moist. Older plants which are quite woody take on a sickly, weak, yellowish appearance, wilt at the top, slowly die, turn brown, and dry up. Nearly mature plants which are attacked, but not yet dead, are easily pulled up, the roots breaking off easily at about the level of the furrow slice.



Sketches showing clumps of young flax plants which have wilted, due to early attacks of the wilt fungus from flax sick soil. Original.

Upon examination, most of the smaller branch roots are found to be dead, as well as the tap root below the point at which it breaks off. These dead roots and the parts of the tap root already diseased have a very characteristic ashen gray color. Many nearly mature plants which are attacked late in life show this dead gray down one side of the tap root only. The leaves, side branches, and a strip of the main stem above this portion are dead, giving a peculiar one sided blighting, similar to the appearance of a tree struck by lightning.

If the disease is sowed with the seed upon breaking, but a few plants are attacked the first year; and, at flowering time, dead plants will be seen to be quite evenly distributed in the drills. If weather conditions are quite favorable, each new infection increases sufficiently in area to reach over and attack plants in two or three adjacent drills. These infection areas are nearly always circular in outline, and become much enlarged if flax is seeded there the following year. The first year these spots may reach a diameter of one to three or four feet. The second year these same areas are usually much more than doubled, so that it takes but three to five flax crops upon such lands to make the infection general. Mr. John Anderson of Hillsboro reports a typical case. "The field used was for many years a cow pasture and very fertile. The first year of flax in this soil gave a very fine crop, disease not noticed. The second year gave a fair yield per acre, but the field was spotted. The third year a very poor crop was grown, hardly worth harvesting. This year there were large areas in which no flax plants grew, and the crop became thinner and thinner until there was not a full stand of plants in any part of the field at harvest time." This case fairly represents what may be expected if disease bearing seed is sown each year.

Because of the peculiar and characteristic manner in which all young plants and the soft parts of more mature ones droop and wilt when attacked, as if through drought or intense heat, I have called the disease *flax wilt*. Though the trouble may be properly referred to as *flax sick soil*, I think *flax wilt* will prove distinctive.

EXPERIMENTS SHOWING THAT THE DISEASED SOILS HAVE NOT LOST FERTILITY OR ACCUMULATED CHEMICAL SUBSTANCES DETRIMENTAL TO FLAX: It seemed from the start desirable to determine whether Prof. Lugger's conclusion, that a flax crop leaves some substance in the soil which is "unkind" or poisonous to following flax crops, is tenable. It has been shown by Snyder's analyses * that a flax crop does not draw more heavily upon the important plant foods of the soil than other common crops. The Chemist of this Experiment Station has also arrived at a similar conclusion, through analysis of the soils taken direct from the rotation plots on the College Farm; and Prof. Shepperd ** has shown, by comparing actual yields, that wheat and other crops do especially well after flax. I have also observed that common sorts of weeds are able to take full possession of the infested areas upon which flax can make no further growth, and in 1901 good crops of wheat, oats, corn, potatoes, and beets were grown upon the diseased plot, No. 30. All these features tend to prove that the soil is not rendered infertile by flax. It was found comparatively easy to prove this by means of a simple biological experiment.

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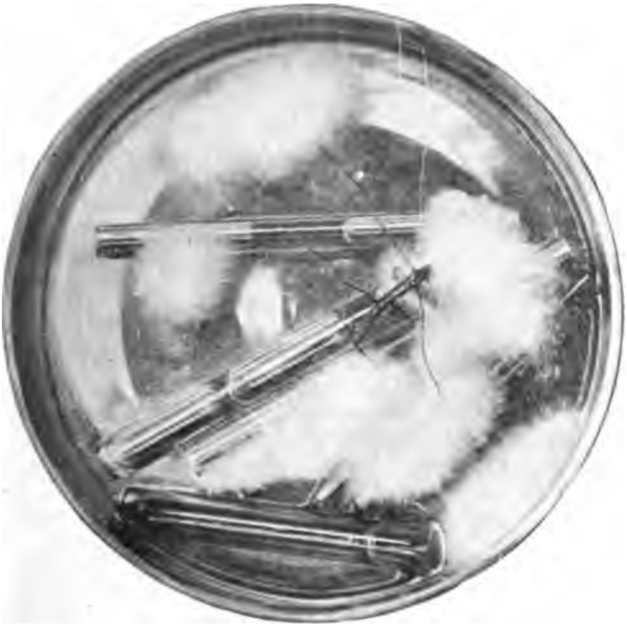
* See this bulletin page 31.

** North Dakota Experiment Station Bulletin No. 39, page 451.

Experiment No. 1. Soil was taken from rotation plot No. 30, upon which it has been found impossible to produce a mature flax plant since the year 1890, and was subjected to a process of steaming sufficient to kill all living organisms. Upon this soil flax seeds which were treated in any way that would kill or insure the removal of all disease germs produced a perfectly normal growth of flax.



Photograph of a pure culture of the flax wilt fungus (*Fusarium lini nov. sp.*) growing upon sterilized flax roots. (Original)

Several experiments of this type have conclusively settled the question of soil depletion. It also does away with the idea that old flax straw decaying in the soil can produce some substance which is poisonous or detrimental to the growth of flax plants, for there was plenty of such decaying matter in the soil used in these experiments. *

THE CAUSATIVE AGENT IS A FUNGUS PARASITE: By experiments in 1900 and 1901, I have been able to prove definitely that the disease is not due to soil impoverishment or to any chemical substance left in the soil by the decay of flax roots and stems. It is also proved that a definite species of fungus is the direct cause.

HISTORY: That we have been able to accomplish this so definitely is not due to an accidental or lucky find of a parasite. When I first met Dr. Lugger in the fall of 1890, he called my attention to the fact that "Flax is subject to the attack of a strange disease which has appeared in some counties of Minnesota." Since that date I have made each year some observations in flax fields, and have collected some specimens, attempting to ascertain a direct cause. Many microscopic sections were, from time to time, made and studied, but were negative in result until pure cultures, made during the summer of 1900, defined the organism to be looked for. Many previous attempts to obtain pure cultures had failed because of difficulties which were found hard to overcome, even when an abundance of diseased plants and soil was close at hand. This condition was made possible through the kind co-operation of Prof. J. H. Shepperd, the Agriculturist of this station. In the summer of 1893, Prof. Shepperd agreed to crop one of his regular one-eighth acre rotation plots continuously to flax until something should happen. This something came markedly to notice July 1st, 1900, when all of the young plants on the flax plot were found to be dead or rapidly wilting. The records for this plot show that in spite of improved drainage and cultural methods, which had sufficed to raise the standard of all other crops upon the adjacent plots, the yield of flax was less each year after 1895. In 1899 it dropped from 12.3 bushels, the yield of 1898, to 7.4 bushels. In 1900 all plants were dead by the Fourth of July. At this time Prof. Shepperd turned the plot over to the Botanical Department for investigation. I have since been unable to get any flax plants to reach maturity upon the soil of this plot. Indeed, most plants succumb before reaching a height of three inches. This plot is known in the College records as Rotation plot No. 30.

The following are a few of the observations which, from the first, led me to the conclusion that the disease must be due to a minute plant organism: (1) The disease was observed to be able quickly to destroy all plants over large areas; and plants of all ages died of essentially the same symptoms. These observations seemed sufficient to exclude the work of insects. No insect known could multiply with sufficient rapidity to accomplish such work, and the injury done was of too fine and even a type. (2) The disease was observed to spread rapidly and uniformly through the soil, and was able to persist in the infected areas several years without the crop which it attacks. These features especially pointed to a probable fungoid origin. (3) The disease was seen to spread most rapidly in the line of the surface wash waters. (4) In the infected spots, plants were often found which showed only one blighted side. This dead side is most often nearest the center of the soil infection. (5) The disease was found to spread most rapidly in fertile soils and more rapidly in those of a strongly alkaline type than elsewhere. These two features are especially characteristic of low forms of fungi, including certain bacteria. (6) Areas of diseased soil were often found at and adjacent to points where masses of flax straw had been allowed to decay, the areas of new infection being too great to be attributed to any chemical substance bleached from the straw. (7) The disease was often seen evenly distributed in the drill rows upon breaking, indicating the probability that it had been sowed with the seed.

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* Since this work was accomplished, I learn through the report by Nypels that Broekema had previously conducted a similar sterilization experiment, arriving at like results, though no mention is made of seed disinfection which is strictly essential to make the experiment of value in drawing the conclusion. (See reference cited on page 30 of this bulletin.)

These points, together with oft repeated experiments which showed that the infection of new soils could be accomplished through the use of infusions made from the soil of diseased areas and from sick plants, left slight doubt that the disease must be caused by a parasite possessed of such great powers of multiplication and disease production as are only found in the low forms of fungi. It also seemed probable that it must be able to live a part of its life as a decay form *(saprophyte)*.

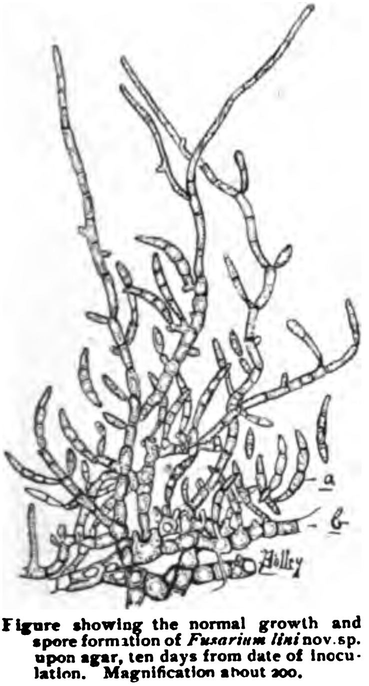

Figure showing the normal growth and spore formation of *Fusarium lini* nov. sp. upon agar, ten days from date of inoculation. Magnification about 200.

THE FUNGUS AND HOW PURE CULTURES WERE OBTAINED: The fungus which produces the disease belongs to a genus of minute plants which botanists have called *Fusarium*. As it appears to be a species which is new to botanical descriptions, I shall call it *Fusarium lini* * after the plant which it attacks.

Much difficulty was experienced in procuring a pure culture of an organism which could attack a live flax plant. The difficulties arose chiefly from the presence of numerous miscellaneous fungi and bacteria which are always present in the soil, upon and within the decaying parts of the diseased plants. The fungus was first procured in pure form July 6th, 1900, by the following method: Stems of moderately

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*** FUSARIUM LINI Nov. sp. Vegetative hyphae, light colored, .7--3 m. m.**

mature green flax plants, which were just beginning to wilt, were selected. Four inches of the apparently healthy main stem was cut out, stripped of its leaves, washed in distilled water and soaked two minutes in a solution of formaldehyde, made by adding two and one-half parts of standard formaldehyde to 1000 parts of water. Clippings made from the internal woody part of these stems were placed in a sterile moist chamber. In four days there grew out from the cut ends of these clippings a beautiful down-like white growth of filaments. (See figure in Petri dish.) By a series of baits made from sterile, decorticated, green, healthy flax stems, it was easy to get the fungus transferred to the usual solid culture medias. On these, it makes good growth and fruits abundantly, with quite characteristic effects upon slightly acid agar.

Upon all pure cultures and upon moist sterile soil, the growths made are very rapid, and profuse spore formation begins at once. The spores thus found gave the information needed

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in diameter septate, branching irregularly, ramifying the tissue of the stems and roots of the host. Spore beds (Sporodochia) erumpent, compact, slightly raised, distinct but closely grouped upon the stems, pale cream to flesh colored. Sporophores rather short and closely branched, or conidia sometimes arising from wart-like or nearly sessile prominences upon a compact stromatic base. Conidia normally four-celled, fusiform, slightly curved or falcate, copiously produced in a bud-like manner from the stroma and from short branches of the sporophores, 27x3 m. m. to 38x3.5 m. m. Living in the humus of the soil. able to attack the flax plant, producing the disease known as "flax wilt", and causing the soil condition long described as "flax sick soil".

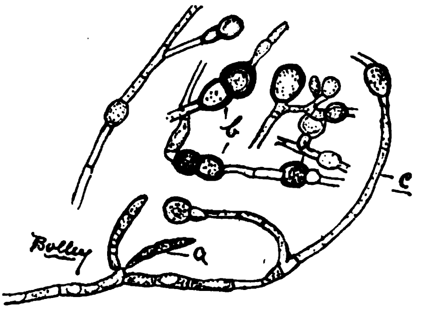


Figure showing some elements of an old pure culture. *a*, Regular conidia; *b*. peculiar chlamydospore-like structures; *c*. filament of the fungus, forming chlamydospore upon its end.

The fungus makes rapid growths under the artificial conditions furnished by the ordinary nutrient culture media, producing a profuse formation of downy white mycelium, from which numerous one-celled, two-celled and four-celled conidia are produced. These rise from the sides of the regular hyphae and upon shorter special side branches. Another form of spore-like body, perhaps of the chlamydospore type. is produced in old cultures and in the filaments found in decaying flax straws. Upon slightly acid pepton agar the fungus develops a beautiful wine color in the substratum. All the different types of spores germinate profusely whenever proper moisture and temperature is given. and they exhibit a peculiar fusion of the filaments similar to that exhibited by the sporidia of certain of the Ustilagineae. (See cuts.)

It may be that this same fungus is parasitic upon some other plant and thus may have been described previously. If so, no great harm can be done to botanical science in the addition of another synonym. Indeed, to the student of parasitology, synonyms prove of much value.

to cause the recognition of a fungus which had been observed with the disease before. Since that time it has been found associated with all specimens of the wilt examined, and it is always to be obtained in the soil of infected areas.

Although the different spore forms were found in 1900 by studies upon culture medias and upon humus and decaying flax rubbish in diseased fields, the typical Fusarium spores were not found upon living plants until July 11th, 1901. These spores seem to occur above ground only under certain favorable conditions.

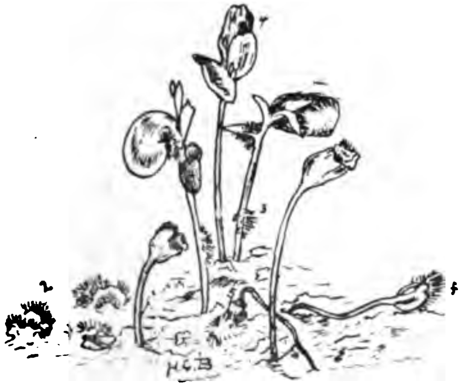
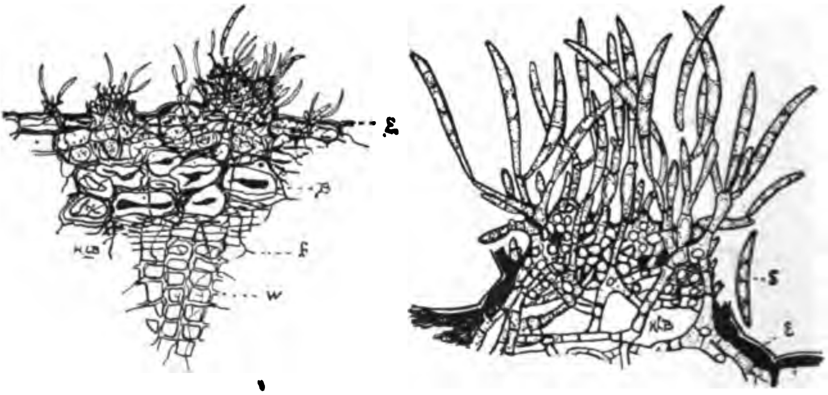


Figure showing the ability of a pure culture of *Fusarium lini* to attack young flax plants when applied at different points. *5* and *1* young plants killed early, attacked from the soil. Plants *3* and *4* were attacked upon the sides of the stems and upon the seed leaves.

Mode of Attack: Though living normally as a decay form, (*Saprophyte*) this low type of fungus can also invade the living tissues of its host. It produces spores quite normally, both in the humus and upon the tissues of plants which are just dying of wilt. As it can live and increase upon the decaying matter found in soils, especially upon old roots and stems of flax, it can readily thrive there for a long period. Observations made on the rotation plots of the College Farm and upon fields elsewhere indicate that it may not only remain in soil more than four years without the presence of a flax crop, but it can also gradually spread as shown by the effect upon following crops.

The filaments ramify the soil thoroughly and produce an abundance of spores, which may germinate at once. If any of the filaments come in contact with a young flax plant, they penetrate it at any point, through the seed leaves, stem or roots. As soon as the plant dies, it becomes food material for the fungus. On and in such dead parts, numerous spores are soon produced and are carried through the soil by washing of rainwater, etc. The more nearly matured plants are principally attacked by way of the roots. They die slowly and may even ripen seed, apparently maturing early. Sections through the stems and roots of such plants show that the parasite is able to penetrate the cell walls at any point, passing directly through any of the tissues, even including woody parts of the stem. The filaments are, however, in greatest abundance throughout the bark (*cortex*) layer of the stem and roots. This softer tissue of the flax plant is often quite disintegrated. Following the parasite, other decay forms rapidly complete the work of cell destruction, and the plant wilts.

The Fusarium produces spores normally upon the base of the main stems of the attacked plants. The spores get into the seed at threshing time, being rattled from the side of diseased straws. If the grain at the time is slightly damp, the spores get glued to the seeds, and thus are in position to attack the seedling as soon as germination occurs. Numerous plants are thus killed before reaching the surface. As the spores and particles of the filaments (*mycelium*) stand air drying for long periods, and are able to sprout as soon as moisture is applied, it will be clear to any one why the disease can spread so rapidly and do so much damage.



Figures showing clumps of spores which the *Fusarium* usually produces upon the sides of mature flax stems. The drawings are made from cross sections of a flax stem, through the spore beds. The figure on the left, in low magnification, indicates how the filaments ramify the tissues: *b*, bast fibers; *w*, wood cells; *f*, fungus filament; *e*, epidermis; *s*, mature spore. The magnification of the figure on the right is approximately 400 diameters.

The Influence of Soil and Climate: The fungus does not seem to have a great preference for soils. I have found it upon all types of land in North Dakota. It probably will thrive upon any land which is sufficiently fertile to produce flax. It makes, however, a most rapid growth upon a rich humus; for example, in a number of indoor tests, it spread with greatest rapidity through a sample of well pulverized virgin sod. Other features being equal, it seems to be most destructive upon strongly alkaline lands, thus the application of lime seems to increase its development. The most general damage to the crop occurs under conditions of drought and upon loose, friable soils. Atmospheric conditions seem to have little to do with the disease, except in so far as they directly affect the physiological processes of the flax plant. A certain degree of moisture is, of course, necessary for a large development of the fungus in the soil, and the spores are produced in greatest abundance on the stems above ground in a humid atmosphere.

How New Areas May Become Infected: Apparently this disease will be a more difficult one to deal with than wheat-smut; because the fungus of flax wilt can live and spread through the soil. Outlines of a few of the experiments, which have proved the disease to be an infectious one, will make this point plain.

INFECTION EXPERIMENTS IN THE FIELD: These Experiments were conducted upon a field, which probably had never previously borne flax.

Experiment No. 1, July 4, 1900.. Some fine dirt particles were taken from plot No. 30 and were scattered upon the surface of a bed of young flax. Result: Many plants died of the disease before maturity. A check bed kept for the purpose remained free from the disease.

Experiment No. 2, July 4, 1900. Some young flax plants were watered with water in which some soil from plot No. 30 had been soaked. Result: The young plants were soon attacked, showing many wilted ones on the date, July 19th.

Experiment No. 3, July 4, 1900. Some plants which were just coming through the soil were watered from a cold infusion, made by soaking wilted flax plants. Results: July 19, the disease took full charge of the bed, and plants were found dying.

Experiment No. 4, July 4, 1900. Diseased flax straw was buried in a bed and flax was seeded over the top of it. Result: Plants became thoroughly diseased.

Experiment No. 5, July 22, 1900. A number of young plants were watered with a few quarts of water into which was stirred the fungus growth from several pure cultures upon agar. The plants at this time were about three and one-half inches high. Result: Six of the plants out of a possible eighteen died of wilt before reaching maturity. It was found that a thorough boiling of any one of the infection materials caused it to lose the power of producing disease.

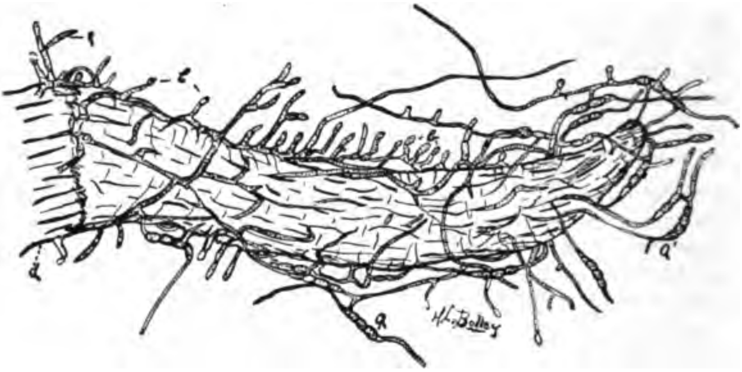
Experiment No. 6, July 10, 1900. Flax seed was received from Mr. John Anderson of Hillsboro. Mr. Anderson stated that his flax crop had been a "spotted failure" in 1899. Some of this seed was sowed. Result: Nearly 50 per cent. of the plants which came up in this bed died of wilt before reaching maturity.

Experiment No. 7. The area of ground upon which these experiments were conducted in 1900 was seeded to flax in 1901. The seed used was treated to kill any flax wilt spores which might happen to be in it. Results: One could easily find the spots upon which the infection experiments were made in 1900 by the presence of the dead and dying plants. Each spot was much enlarged and no flax could live in the center of any one of the spots.

INFECTION EXPERIMENTS IN THE LABORATORY: Many different kinds of infection tests have been carried out in the laboratory.

Experiment No. 1, June 17, 1901. Virgin soil was taken from beneath native prairie sod. The plants were watered with distilled water. Fifty seeds were planted in each of eight rows.

Row 1, seed from Christ Bang, McCanna, quality weak.
Row 2, seed from N. E. Kringler, Buffalo, scaly.
Row 3, seed from D. A. Langworthy, Corinne, fair quality.
Row 4, seed from Grandin Farm, Mayville, fair quality.
Row 5, seed from J. M. Thompson, Ayr, rather weak.
Row 6, seed from point unknown, of weak quality.
Row 7, seed from N. A. Kloster, Aneta, quite sound.
Row 8, seed from College Farm, fair quality.



A rough sketch, showing the mode of attack upon a young root tip of a seedling flax plant. *a*, germinating spores which have sent their filaments into the root; *b*, new spores beginning to form upon filaments arising from the tissues of the root after infection; *c*, a nearly mature conidium; *d*, unattacked part of young plant.

Results: June 26, Row 1, 26 plants up, all sound, ground not infected from seed.

Row 2, 13 plants up, seed leaves dead in some cases, and soil infected from many of the dead seeds.

Row 3, 33 plants up, from strong seeds, 11 wilting from the disease, fungus seemed to be growing from many of the seed pods, ground infected from almost all seeds.

Row 4, 30 plants up, one attacked by wilt.

Row 5, 32 plants up, none attacked by wilt. No infection of the soil from the seed.

Row 6, 21 plants up, 7 dead from wilt.

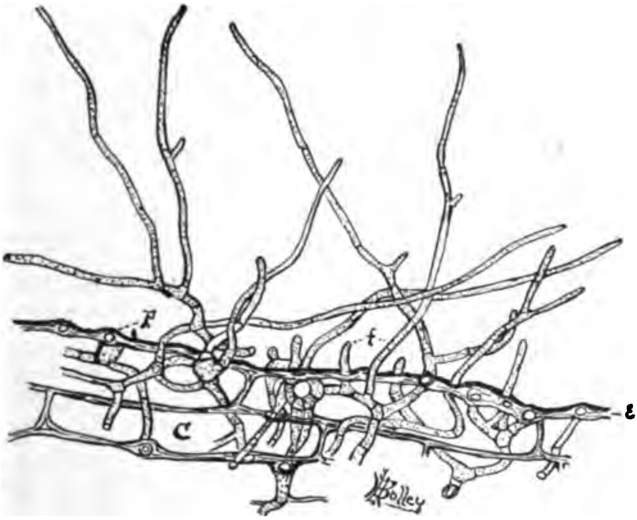
Row 7, 33 plants up, 3 dead from wilt. Wilt spreading in the soil from these three and from some dead seed.

Row 8, 40 plants up, 7 killed by wilt fungus and the soil infected in several spots. The plants in this experiment were sufficiently distant from each other to allow one to note the spread of the fungus in the soil, which can readily be done under the conditions of indoor culture. July 4th the fungus had spread sufficiently from infection spots to reach and kill all plants.

Experiment No. 2. Seeds from the College Farm were treated with hot water so as to kill all spores upon them. They were planted in virgin, sterile soil and watered with distilled water. The plants remained healthy and the soil free from disease until artificially infected. The infection was accomplished in each of the following ways. 1st, from spores taken from old flax straw; 2nd, from seeds which had not been disinfected; 3rd, from soil particles taken from a flax sick spot in a field; 4th, from dried filaments of the fungus, air dried one year; 5th, from a pure culture of the fungus, which had withstood air drying in the laboratory one year; 6th, from fresh spores raised on pure cultures; and 7th, from bits of chaff and flax straw one year old. In the case of the seven tests, the infecting elements were the three different types of spores which the fungus produces, and also new growths from old filaments. (hyphae.)

The conclusion from these experiments would seem to be that the disease is widely distributed throughout the state, that some samples are much more thoroughly infected than others, and that new fields may become infected in any of the following ways: 1, by means of soil particles carried in any manner from diseased areas; 2, by drainage waters from such diseased spots; 3, by diseased flax straw; 4, by flax seed which has been threshed from a diseased crop. It was also learned that the virgin soils of the prairie are probably quite free from this species of the Fusarium; and that the fungus which is pictured in this bulletin is the real cause of the flax wilt disease, and of "flax sick soil."

EXPERIMENTS TO DEMONSTRATE THAT THE DISEASE MAY BE PREVENTED BY SEED TREATMENT: Various experiments have been made to find some substance and method which may prove effective in seed treatment for prevention of the disease; for it is evident that there can be no hope of escape from this soil trouble unless all flax seed is disinfected before planting.



A portion of a longitudinal section of a young root of flax, attacked by the *Fusarium* of flax wilt. *c*, cells of the root; *e*, epidermal wall; *p*, note openings in the walls, showing how the fungus bores its way through the cell walls; *f*, aerial filaments of the fungus extending into the soil.

The *hot water* method helped to show that the disease may be communicated by the seed, and that the spores can be killed without killing the seeds, but it is not a practical method as the seed soon softens and gums, or masses like a poultice. The dipping process has proved a failure with all sorts of solutions for a like reason. It can be done for experimental purposes but cannot be carried into field practice. Treatment with gas from formaldehyde seems difficult to control; both seeds and spores are killed or injured with great irregularity. However, a method of treatment has been found possible and successful. The following is an outline of some of the preliminary experiments:

EXPERIMENTS WITH FORMALDEHYDE: Experiment No. 1. The seed used was from the College Farm and known to bear Fusarium spores. The strength of solution was one part of formaldehyde to 400 of water. The seed was soaked from one to sixty minutes, then allowed to dry. Each sample was planted on a field which was free from disease. Results: All seeds, dipped longer than three minutes failed to grow. The treatment was too strong in all cases, but no plants produced the wilt fungus. A check plot from the untreated seed produced many wilted plants.

Experiment No. 2. The seed used was much infected, strength of solution, 1 part to 200. The seed was treated by a fine spray, and at the same time was thoroughly shovelled over. All grains became evenly damp but not wet enough to gum or mat. Result: There was a good growth of plants in the field, but the treatment was heavy enough to injure some seeds. The crop at harvest time was free from wilt.

Experiment No. 3. The seed used was mixed with pulverized chaff and broken straw from plants which died of wilt in 1900. The strength of solution used was 1 part to 200. The grain was treated by the sprinkling and shovelling method. Results: The disease made its appearance in some places in the beds. These infections were found to arise from the bits of chaff and straw. Studies were made of such particles of diseased straw, and it was found that filaments of the Fusarium could grow out from the tissues after the latter had been soaked in a solution of much greater strength than flax seed can withstand. The solution failed to reach the fungus under such protection. In the untreated check on this experiment, the disease was so heavy that practically all plants died before maturity.

Experiment No. 4. The seed used was weak, screened from college flax, and was full of wilt spores. The strength of solution was 1 part to 200. The method was by sprinkling and shovelling until the grain was evenly damp. It was left slightly piled one day before it was seeded. To finish the treatment it took approximately one-half gallon of solution per bushel of seed. Result: Fine crop of plants at harvest time and no wilt appeared in the bed during the season. The untreated bed from this seed produced scarcely half a crop and was thoroughly sick with the wilt disease.

Experiment No. 5. The Effect of Formaldehyde upon Fusarium Spores and upon Flax Seed. In these tests the spores and seeds were dried at once.

Test No. 1. The strength of the solution was 1 part to 400. The seed and spores were each soaked for five minutes, ten minutes and thirty minutes. Results: The seeds were not materially injured by immersions of five to eight minutes, but were much weakened by the longer treatment. The spores were killed in all cases, but the filaments which were located in bits of bark remained able to grow.

Test No. 2. Strength of solution used was 1 part to 250, time of soaking two minutes and five minutes. Results: Seeds were just perceptibly injured by dipping and drying at once, were considerably reduced in strength by soaking two minutes, and were injured fully 50 per cent. by the five-minute treatment. spores were all killed by simply dipping and drying, but filaments of Fusarium grew from bits of straw after soaking five minutes.

Test No. 3. Effect of Formaldehyde upon Fusarium Spores:

(a) Spores soaked in 1 part in 1,000, 15 minutes—some grew.
(b) Spores soaked in 2 parts in 1,000, 5 minutes—some grew.
(c) Spores soaked in 2 parts in 1,000, 10 minutes—some grew.
(d) Spores dipped in 3 parts in 1,000—some grew.
(e) Spores soaked in 3 parts in 1,000, 5 minutes—some grew.
(f) Spores soaked in 3 parts in 1,000, 10 minutes—no growths.
(g) Spores dipped in 4 parts in 1,000—no growths.

(h) Spores soaked in 4 parts in 1,000, 2 minutes—no growths.
(i) Spores soaked in 4 parts in 1,000, 5 minutes—no growths.
(j) Spores dipped in 5 parts in 1,000—no growths.
(k) Spores soaked in 5 parts in 1,000, 2 minutes—no growths.
(l) Spores soaked in 5 parts in 1,000, 5 minutes—no growths.
(m) Spores soaked in 5 parts in 1,000, 10 minutes—no growths.

This experiment gave opportunity to notice the effect of formaldehyde upon the structures of the spores. It is easy to observe when the formaldehyde becomes sufficiently strong to vitally effect the living substance of the spores. The protoplasm becomes granular and more or less shrunken and dead spores have a crenated appearance. If not too strongly affected, a spore may regain its plump form when water is applied. Sometimes one or more cells are killed, the others remaining able to germinate.

The results of these experiments favor the conclusion that a rather strong solution of formaldehyde acting a short time will work most satisfactorily upon flax seed. It was also proved that such a treatment cannot destroy the filaments of the Fusarium which are located inside of bits of flax straw; hence to succeed in treatment for prevention, farmers must clean the flax thoroughly, so as to remove everything except the seeds which are to be sown, before subjecting the grain to the treatment. The chaff, etc., should either be burned or so disposed of that it does not get into the manure pile; for the fungus could easily be taken from there to new fields.

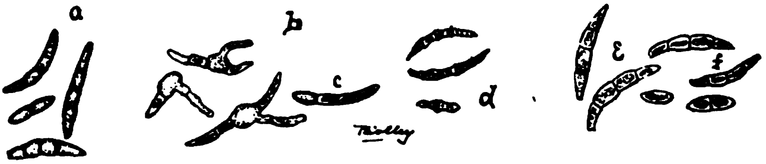


Figure showing: *a*, Normal untreated spores of *Fusarium lini*; *b* and *c*, the same after a weak treatment with formaldehyde--some cells are yet able to germinate; *d*, spores which were killed by formaldehyde; *e* and *f* show the effects of different strengths of corrosive sublimate solution.

Experiment No. 6. A Study of the Effectiveness of the Sprinkling and Shovelling Method. Two grades of seed were used in the trial; that of grade No. 1 was a very fair quality, well cleaned but infected; that of grade No. 2 contained many seeds of weak and scaly type. The grain in each case was placed in a pile upon a tight floor and shovelled and hoed over rapidly, while the solution was sprayed upon the pile by means of a small spray pump.* The seed of grade No. 1 was treated with a solution of the strength of 1 part to 200; that of grade No. 2 with a strength of 1 part to 400. The grain, in each case, was made thoroughly damp throughout, but not wet enough to gum together. This was accomplished by much shovelling while the water was applied. A portion of each was spread so as to dry at once, the rest was left piled about one foot deep. The next day both piles were found to be dry; the moisture had in part evaporated and in part been absorbed.

GERMINATION RECORDS FOR THIS EXPERIMENT: (a) Test of seeds from grade No. 1: 100 bright, plump seeds were taken from the center of the pile, 100 from the seeds on the outside of the pile, 100 from those which were dried at once, and 100 similar untreated seeds. Results: On the 4th day, it was evident that the seeds from the center of the pile were less strong than those from the outside of the pile and those which were dried at once, while the latter were quite as strong as those from the untreated lot. On the 8th day the plants were counted.

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* A fine nozzled sprinkling can will do for this work, provided one is careful not to sprinkle on too much solution before shovelling over.

1, from center of pile, 74 normal plants, 19 imperfect and 7 dead.
2, from outside layer, 92 normal plants, 6 imperfect and 2 dead.
3, from seeds dried at once, 96 normal plants, 3 imperfect and 1 dead.
4, from untreated seeds, 78 normal plants, 14 imperfect and 8 dead.

The Fusarium, an Alternaria, and some common moulds attacked the untreated plants, while the treated grains remained clean. This, perhaps, accounts for the final growths from numbers 2 and 3, being better than those from the untreated seed.

(b) The tests of seeds from grade No. 2 gave the following:
1, from center of pile, 82 plants of normal form, 10 imperfect, 8 dead.
2, from outside layer, 72 plants of normal form, 10 imperfect, 18 dead.
3, from seeds dried early, 71 plants of normal form, 14 imperfect, 15 dead.
4, from untreated lot, 73 plants of normal form, 12 imperfect, 15 dead.

In this set of tests some Fusarium spores grew on seeds of 2, 3 and 4. No. 1 gave best results.

Experiment No. 7. Germination tests upon infected seeds, treated and untreated and planted in sterilized soil to note the effectiveness of seed treatment for prevention. The seed used was infected, scaly flax of weak and immature type.

1, untreated; 2, dipped in formaldehyde 1 to 1,000; 3, dipped in 1 part to 400; 4, dipped in 1 to 250; 5, in 1 part to 200. The seeds were planted at once after treatment on July 10th. Results:

On July 15th the conditions were as follows: No. 1, 56 plants up, eleven plants attacked, lots of infection.
No. 2, 62 plants up, two or three soil infections from the seed.
No. 3, 57 plants up, one wilt infection found.
No. 4, 47 plants up, no wilt infections.
No. 5, 59 plants up, no wilt infections found.

The tests under experiment No. 7, considered in connection with many others, indicate that the proper strength of formaldehyde solution to be used in the sprinkling and shoveling methods is about 1 part to 330 parts of water (approximately one pound to 40 gallons), and that the best strength of flax germination will be obtained by shoveling or handling the grain over after treatment sufficiently to get it dried out at once.

OTHER TREATMENTS POSSIBLE: Numerous tests have been made with other fungicides and with various substances which gave promise that they might be more easily applied in practice than formaldehyde. Rather satisfactory results have been obtained from some of them, but as none are yet under proper control, the details of the tests will not be given at this time. The following stubstances have been studied as to their effects upon the growth of flax seed, and upon the development of the Fusarium: salt, lime, hot water, hot air, alcohol, flowers of sulphur, iron sulphide, copper sulphate, formaldehyde gas, corrosive sublimate, creolin, creosote, kerosene, gasoline, turpentine, gasoline and turpentine, gasoline and creosote, gasoline and creolin, gasoline and carbolic acid, and carbolic acid.

Of these substances copper sulphate and corrosive sublimate prove quite effective, but show no quality which in farm practice would give them preference over the formaldehyde.

As flax seed when wet readily gums or masses in cakes, it has been thought very desirable to obtain some dry treatment. As yet this has not been accomplished. Salt, lime and sulphur are ineffectual against the spores, indeed, appear beneficial to the growth of the fungus, when applied in strengths which are injurious to flax. Hot water gums the seed at once. Formaldehyde gas is unmanageable in practice, and the seeds are killed irregularly.

It would prove very acceptable to farmers if one could develop a quick drying liquid process. For this reason gasoline and turpentine each seemed promising. Seed treated with these substances dries at once and becomes very mobile, suitable for running through the drill; but, strange as it may seem, both flax seeds and the spores of the Fusarium withstand soaking in these oils for long periods of time without effect upon their powers of germination. Thus, both germinated freely after being immersed for three days in gasoline of commercial strength. Both spores and seeds germinated well after soaking 15 minutes in a 50 per cent solution of *turpentine* in gasoline. A few trials with 5 per cent *carbolic acid* in gasoline also showed that this substance only slightly retards the growth from the spores.

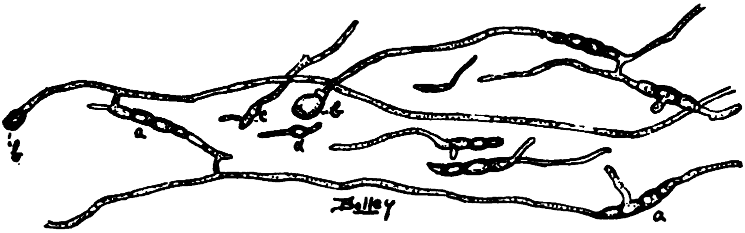

Figure showing the characteristic germination of the regular spores, conidia, of *Fusarium lini*, nov. sp. *a*, regular spore; *b*, secondary spores formed just after germination; *c*, two-celled spore; *d*, one-celled spore. Note the peculiar fusion of filaments. This seems to occur before the secondary spores begin to form.

Further efforts will be made along these lines, but even gasoline has many qualities which would be against its use in farm practice. It is thus pleasing to know that it is really but little more difficult to apply the formaldehyde treatment to flax, per acre, than for oats. The only point with regard to the difficulties encountered in treating flax is that it must be cleaned thoroughly before treatment, and one must be somewhat more careful when applying the treatment. The solution must be applied slowly and evenly and not too much, just enough to evenly dampen the surfaces of all seeds. One must also be very careful to dry the flax out at once after the treatment.

POSSIBILITY OF SOIL TREATMENT: Tests have been made to determine the effects of various chemical substances and different fertilizers upon the disease, by applying such substances in large amounts directly to infected areas.

Experiment No. 1. July 4, 1900. The soil used was that of rotation plot No. 30. There had been five crops of flax upon this land. At this time the sixth seeding had just finished dying by wilt, the oldest plants being from 3 to 5 inches high. A portion of the plot was spaded into a number of garden beds, 4x4 feet each. Three rows of the same kind of flax seed were planted in each bed. The seed was planted in shallow drills, and one-half of the substance to be applied in each case was sprinkled in the row, around and over the seed. After the drills were covered, the other half of the substance was scattered evenly over the surface of the bed and slightly raked in. All of the substances used were first thoroughly pulverized, and the following beds were planted: Bed 1, untreated; Bed 2, kainite, 1 pound; Bed 3, nitrate of soda, 1 pound; Bed 4, "Complete fertilizer", 1½ pounds; Bed 5, superphosphate, 1 pound; Bed 6, cow-dung, 2 quarts; Bed 7, sheep dropping, 3 quarts; Bed 8, potassium sulphate, ½ pound; Bed 9, carbonate of soda, ¼ pound; Bed 10, chloride of lime, ¼ pound; Bed 11, oxalic acid, ¼ pound; Bed 12, iron sulphate, ¼ pound; Bed 13, potassium nitrate, ⅛ pound; Bed 14, calcium phosphate, ½ pound; Bed 15, sodium chloride, ½ pound; Bed 16, calcium sulphate, ⅛ pound; Bed 17, magnesium sulphate, ⅛ pound; Bed 18, untreated; Bed 19, composted barnyard manure, 1 peck; Bed 20, copper sulphate, ½ pound; Bed 21, lime, air slacked, one quart, evenly distributed in the top inch of soil. Results: July 19, 1900. The flax came up rather evenly and well in all beds after several good showers, but commenced to wilt at once with the disease, many being dead at this date. August 8th, all plants were found to be dead. They were killed by the wilt fungus, as shown by studies made in the laboratory.

Experiment No. 2. May 13, 1901: Professor D. B. Halsted has recommended flowers of sulphur as a fungicide to be used in infected soil.* It has been found to be ineffective against the flax wilt fungus, as is shown by the following tests. In each case flax wilt spores were sowed with the seed.

Test No. 1. 4 parts of sulphur were sowed with one part of seed flax. Results: Jan. 27, good stand of flax, many sick of wilt; Sept. 4, crop matured, but fully one-half of the plants had died of wilt.

Test No. 2, same as No. 1, only a large quantity of the sulphur was hacked into the bed between the rows. Results: About as in test No. 1.

Test No. 3, July 12. Soil was taken from beneath virgin sod, placed in flower pots and steam sterilized. Flowers of sulphur were then mixed with the soil as follows: Pot 1, 1 oz. of sulphur to 5 oz. of soil; Pot 2, 2 oz. of sulphur to 5 oz. of soil; Pot 3, 3 oz. of sulphur to 5 oz. of soil. Fusarium spores were planted beside each seed used. Results: Three days after planting the fungus was seen to be making a heavy growth. Later, some plants came up in each pot, but most of the seedlings were killed by the Fusarium before getting through the ground. Finally all plants died of wilt, but the Fusarium made a luxuriant growth in the yellow mass. It invaded the porous sides of the pots and produced spores in quantity upon the outside in the open air. Indeed sulphur seemed to increase the growth of the Fusarium.

Experiment No. 3, July 12. Special Experiments with Salt: The soil used was prepared the same as in test 3 of experiment 3, salt being used instead of sulphur. Pot 1, ⅛ oz. of salt to 5 oz. of soil; Pot 2, ¼ oz. of salt to 5 oz. of soil; Pot 3, ½ oz. of salt to 5 oz. of soil. Results: July 24, salt too strong, no growths of plants in any pot but the Fusarium had rapidly invaded the soil and was producing spores in abundance.

Experiment No. 4, July 12. Air slacked lime was applied in the same manner as that indicated for sulphur and salt. As a chemical treatment of soil, it also is a failure. The Fusarium makes better growth when it is present in excess than in ordinary soils.

It is evident that fertilizers and manures cannot help the flax to resist the disease, and that one can have little hope of finding any chemical substance which will destroy the fungus in infested soils without killing the germinating flax. We must therefore probably look to seed treatment and proper crop rotations to overcome this soil trouble.

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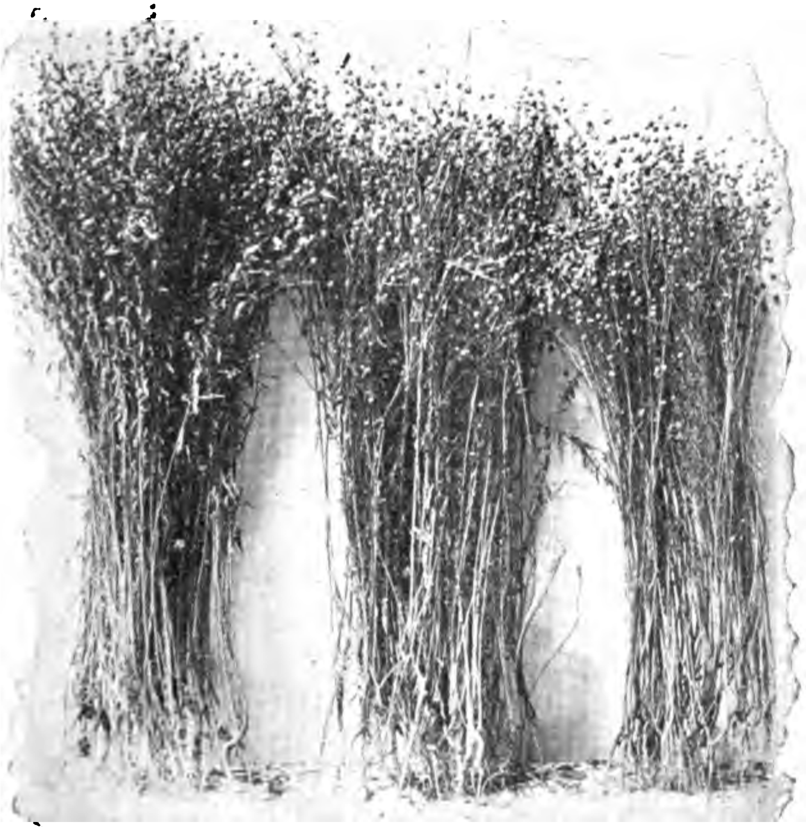
* New Jersey Experiment Station Report for 1895, page 267.



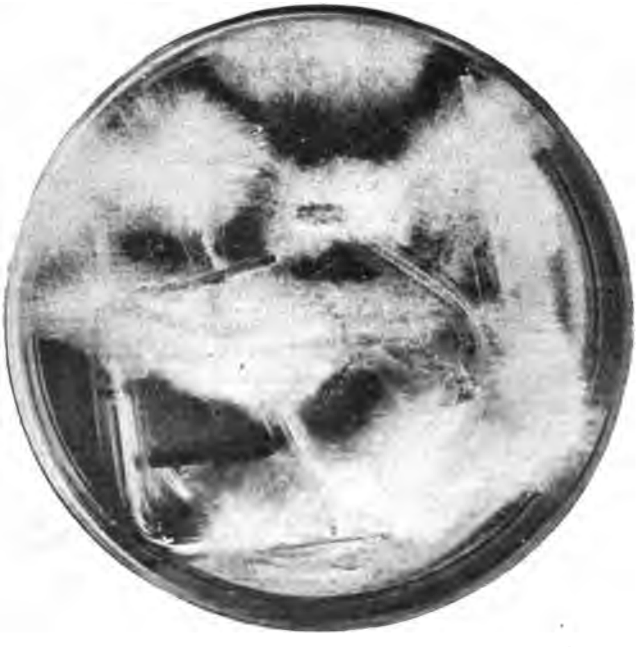
A photograph illustrating the effectiveness of a proper treatment of flax seed for the prevention of flax wilt. Bundle No. 1 shows the growth from a formaldehyde treatment; bundle No. 2, from untreated seed; bundle No. 3, from untreated seed planted with an extra infection of the spores of the flax wilt fungus. Each bundle represents the entire crop from the same area of ground.

Crop Rotations: As yet nothing very definite can be said along this line. We have only the experience of Belgian and other European flax growers to draw from. Their rotation series are always long ones, introducing more kinds of crops than we can well do here, in our extensive field cropping. In the best flax growing districts of the Netherlands, the land is used for that crop about once in ten or eleven years. In this way the crop is kept up to the standard. It is possible that such long rotations rid the soil of this and other destructive diseases. Professor Lugger has said that he could find no apparent common system in these rotations. They seem to be matters of local origin and are kept up simply because they give good results in the crops concerned. The following series will illustrate about the average type of rotation used there upon heavy lands: turnips, oats, clover, clover, wheat, flax, wheat, beans, wheat, potatoes, wheat, oats, and flax. It will be an advantage to us to find some shorter cut from flax to flax. To that end, we are conducting at the station a series of 12, hand cultivated, rotation beds upon plot No. 30 (the diseased plot). There is much room for hope with us, because it is probable that the Belgians as well as others may have been sowing diseased flax seed each time that flax was placed upon their lands. They may also have applied the disease to new lands by the use of manures infected from diseased flax. Now that we know how to avoid spreading the disease afresh each year, it would seem that the farmers of this state and region ought to have a great advantage over older flax countries in dealing with the trouble.

The method which we intend to follow may be indicated as follows: The soil selected is thoroughly infected, but is fertile. No flax plants can now live upon it. By special methods we find that we can always detect the presence of the fungus in the soil. The plot is laid off into twelve distinct beds 30x33 feet in area. Each bed will be spaded and worked with sterilized tools. Each bed will have its own drainage system and is separated by an alley-way 7½ feet wide. Before each crop is planted, an analysis will be made to determine how abundant the Fusarium is in the bed, how deep it extends into the soil, etc. After the crop is taken off, the analysis will be repeated. The crops placed upon the beds each year will depend upon results of these tests. The yields will be recorded and no fertilizers will be applied.

In 1901, the beds were handled as follows: No. 1, bare fallow (no kinds of plants allowed to live); No. 2, wheat; No. 3, potatoes; No. 4, beets; No. 5, bare fallow; No. 6, oats; No. 7, oats; No. 8, bare fallow plus 20 pounds of salt; No. 9, bare fallow plus 20 pounds of sulphur; No. 10, flax (died when three weeks old); No. 11, sowed corn; No. 12, idle, grew up to heavy growth of all sorts of weeds.

Until more is known upon this matter of rotation, the farmers of the state are earnestly recommended not to sow flax upon land which has previously borne flax, until a number of other crops have intervened. If possible, I think it would be beneficial to take off a crop of wheat; a crop of corn, potatoes or other hoed crop; a crop of oats, barley, or millet; then follow these by some years of grass and pasture. It may be better to have a small area of flax giving a heavy yield every few years than to have to go out of the business entirely. There are reasons for believing that a brome grass sod will have a most beneficial effect toward regenerating such "flax sick" soil.

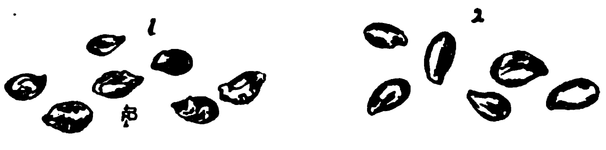


A photograph showing the appearance of a pure growth of *Fusarium lini* filaments arising from the inside of bits of flax straw which had been treated heavily with formaldehyde. This teaches that such bits of straw should be removed before treatment. (Original.)

MEANS OF DISTRIBUTION: *Drainage.* It is evident from all observations that the disease areas tend to enlarge most rapidly in the direction of the surface drainage. From the nature of the spores, and from the fact that great numbers of them are produced in the soil and upon particles of decaying roots and straw, and on the sides of the roots and stems of the sick plants, it is plain that the spores may be carried long distances in the drainage waters after heavy rains. It would seem to be a matter of wisdom to arrange the general drainage of flax fields so that the water may not be carried over other lands.

The Influence of Wind: This is an element of unknown influence in the distribution of the disease. By our experiments we have found that very small particles of soil from the surface of infected areas are sufficient to start the disease in clean soil. We also know that the spores are very numerous and light, and that they stand air drying for long periods of time. It is thus possible that they may be blown from field to field. Many careful observations, however, have failed to convince me that this method of distribution occurs to any marked extent. In rotation experiments upon the College farm, the disease seems to stay pretty well confined to the particular plots attacked. It does not spread very rapidly to the immediately adjacent plots.

Other Means of Distribution: Besides wind and water there are a few ways in which the disease can quite certainly be carried from infected areas to new plots or fields. This may be done by cattle walking over the diseased areas in a wet time, thus easily carrying masses of germ bearing mud and dirt from place to place. Harrows and plows may serve a like end; and the manure pile may easily become the source of much infection, on account of the presence of old flax straw. It is not now known what effect proper composting of manures may have upon the life of the Fusarium.



Sketches showing, *1*, scaly flax seed, and, *2*, smooth, plump flax seed. Farmers should screen out all scaly, immature seeds. They harbor the spores of flax wilt.

THE NECESSITY OF CLEANING AND GRADING THE SEED: One of the most important points in the entire range of flax culture lies in the proper cleaning and grading of the seed. In this state, flax is usually one of the weediest of our crops. This is because farmers have been careless about cleaning the seed for this crop. There are also no types of our farm plants which may suffer more harm from the presence of weeds than flax. This alone would be sufficient excuse for thoroughly cleaning the seed before sowing upon the land, but there are other good reasons for doing so. I have found by experiments that the week, immature, scaly or chaffy seeds are able to carry great numbers of the spores of the wilt disease lodged in the scales or creases. Such seeds are usually soft at threshing time and thus, if spores fall upon them, they become glued to the seed. In one experiment seeds from the screenings taken from a lot of flax seed which was diseased contained a very much greater percentage of flax wilt spores than the plump seed from the same sample. The test showed but two soil infections from 100 of the plump seed taken from the cleaned sample. This sample had been run through the fanning mill but once. The weak, scaly seeds taken from the screenings produced thirty-seven soil infections from one hundred seeds planted. It is thus quite certain that a thorough cleaning and grading of the flax seed would greatly reduce the possibility of infecting new soils with the flax wilt fungus. I earnestly recommend that those who do not think that they have time to treat their seed flax, or are afraid to do so for fear they may, through inexperience, injure the seed, should clean the seed thoroughly. This will remove all weak seeds and tend to cause an even stand of the flax, which is much to be desired, as it is very important in a flax crop that the plants should be of even strength so that they may ripen evenly. The spores of the flax wilt do not seem to be able to cling to good, smooth, plump seeds, unless the flax has been wet or damp at some time. When such good seeds are run through a fanning mill, the loose spores and bits of chaff and dust which carry the disease are blown away.

Figures showing various grades of diseased growths from immature scaly flax seed. All are more or less attacked by the wilt fungus.

HOW TO TREAT FLAX SEED.

There are some difficulties connected with treating flax which are not encountered in handling other grains. When I first recommended the formaldehyde treatment for wheat and oats, a number of farmers complained that they injured their seed. In so far as I have been able to investigate any of those cases, the trouble has been due to some defect in the manner in which they carried out the work. I hope that no farmer will undertake to treat his flax seed until he has read the directions here given very carefully. While the amount of seed to be handled over is much less than in the case of oats and barley, one must do the work very much more carefully. I have only to call attention to the fact that the mere wetting of flax seed, unless it is quickly dried, is injurious to its germinating qualities. One ought, therefore, in treating flax, to be very careful not to use a bit more of the solution than is necessary to dampen the grain. If by accident you should chance to supply more moisture to a batch of seed than you ought to do, throw in some more dry seed at once and stir it over rapidly. The dry seeds will withdraw the excessive moisture from those which are too wet, and thus prevent injury to the latter.

I would not recommend that any one should undertake to treat all his seed flax this year. Try a sufficient amount to sow an area large enough from which to harvest the seed for next year's crop. By another year you may learn to avoid many errors which might now arise through inexperience.

The Method of Treatment: Use formaldehyde at the rate of one pound of the standard strength to forty or forty-five gallons of water (the same strength used for wheat and oats). Spread the seed upon a tight floor or upon a canvas and sprinkle or spray on a small amount of the liquid (a fine spray is best). Shovel, hoe, or rake the grain over rapidly. Repeat this spraying, shoveling, hoeing or raking until the surfaces of all of the seeds are just evenly moist, not wet enough to mat or gum, but evenly damp. (This can be done without matting if the grain is well hoed or shoveled over while the solution is slowly and evenly sprayed upon it). When the seeds are just evenly moist, cease applying the solution, but continue to shovel the grain over so as to get it dry as soon as possible. Avoid any excess of moisture. If flax seeds are dipped in the solution or are allowed to get wet enough to soften the seed coats so that they will stick together, they will be considerably injured or even killed.

It takes less than one-half gallon of the solution to properly moisten one bushel of flax seed.

Caution: One must treat flax with much more care than that usually taken in treating wheat or oats for smut. The solution recommended is strong enough to kill all seeds, if they are made thoroughly wet, or if they are allowed to stay quite damp for some hours.

The grain must be handled over immediately after treatment until it is found to be dry.

Note: The seed should be thoroughly cleaned by running through a fanning mill before it is treated because the solution is not strong enough to kill the disease *(fungus)* which is inside of bits of straw and chaff.

SUMMARY WITH NOTES.

1. There is a diseased condition of flax soils which has long been known to farmers in flax producing regions as flax sick soil.

2. If flax is sowed rather continuously for a number of years upon the same soil this disease tends to thoroughly infect the soil so that flax growing becomes no longer profitable.

3. The disease may be spread by way of the seed flax.

4. The plants attacked die at all ages as if attacked by wilt; hence I have called the disease the flax wilt disease.

5. The direct cause is a minute fungus parasite which grows on the inside of the flax plant, starting either from the seed, or by attacking the roots of older plants if the soil has previously been infested.

6. There are many ways in which the infection might reach new fields, but the chief one is by way of the seed.

7. The seed (spores) of the parasite get into the seed flax at threshing time, rattling off from the sides of the flax straws which have been attacked by the parasite.

8. When such infected flax seed is sown, the spores of the fungus germinate and at once attack the young plants. Those attacked early die at once and there may be no stand even from good seed if the spores of the parasite are abundant. When once in the ground the fungus spreads rapidly, attacking new plants throughout the season. It can live from year to year upon the humus of the soil, hence the soil is soon ruined for flax. Six years

of continuous seeding of flax upon the same plot at the Agricultural College thoroughly filled the soil with the parasite and no plants of flax can live there longer than three weeks.

9. All other farm crops do well upon the flax sick soil. It has not lost fertility for flax, as is proved by experiments which destroy the spores without injuring the soil.

10. The fungus belongs to a genus of plants which botanists have called Fusarium. As this is a new species, we shall call it Fusarium lini.

11. Much of the soil of this state has not yet been infected; but about 50 per cent. of all samples of seed flax yet examined show the presence of the Fusarium spores. It is probable that no sample of flax seed is entirely free from infection.

12. When the soil is once infected no way is known to rid it of the parasite. The fungus is able to live in the soil for many years without the presence of a flax crop to feed upon.

13. The seed flax should be thoroughly graded and cleaned in a fanning mill before treating. This will remove all of the bits of diseased flax straw and chaff which would not be sufficiently treated to kill the fungus inside of them.

14. After treating, it may be well to sow two or three quarts more per acre, as some of the weaker seeds are apt to be killed.

15. Scaly flax seed and seed which has been wet is always very poor for seed. Such seeds harbor the spores of fungi which kill the young plants as soon as the seeds germinate.

16. Cease sowing flax year after year upon the same land. Put at least one cultivated crop and two or more other crops between flax crops.

17. Burn as much of the old flax straw and stubble which remains upon the ground as possible.

18. Raise your own flax seed, grade it up to the best. Watch for diseased areas and notify the station. Thresh your seed, when you can, in your own machine from a patch of strong healthy flax and store it in a clean bin.

19. Keep all the flax straw out of the barnyard, unless it is intended to put all manures through a several years composting process. I cannot say that this process will be successful in de-

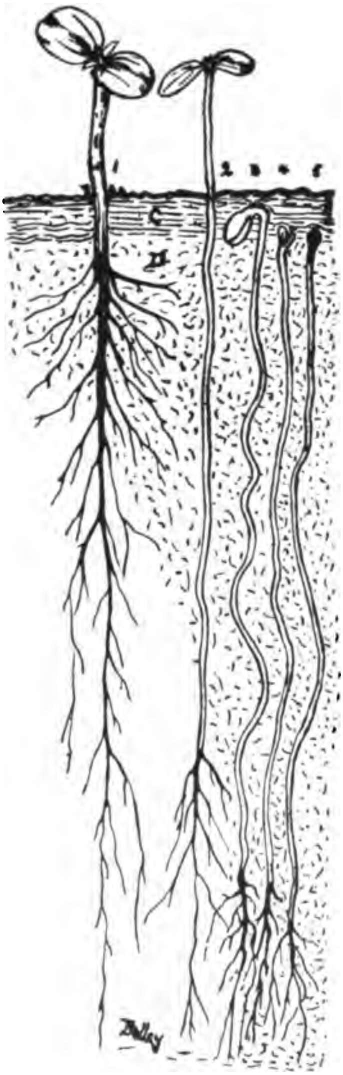
stroying the fungus. It is destructive to most weed seeds and to the spores of many fungi.

20. Avoid the evil effects of deep planting. Much damage is done to the flax crop of the state by too deep planting. The flax wilt disease does more injury to the seedlings when the seed is placed deep in loose soil than when planted shallow. One-half inch to three-fourths inch is the best depth. The seed bed should be of even texture and quite compact.

HENRY L. BOLLEY,
Agricultural College, N. D.

March 1st, 1901.

SHALLOW PLANTING VS. DEEP PLANTING FOR FLAX.



This sketch illustrates the injurious effects of deep planting of flax. Plant No. 1 was planted one-half inch deep; No. 2 was planted three inches deep; Nos. 3and 4 were planted three and one-half inches deep; and No. 5 was put down four inches deep. Such deep planting uses up all the strength in the seeds before the young plants can reach the surface crust, (*c*) then they must die. To get the good results shown in plant No. 1, plant flax about one-half inch deep upon even, compact soil.

To do this best, harrow or roll the field until the surface is even and the soil quite compact, so that the drill will not sink easily into it; then set the drill as shallow as it can be run and yet cover the seed. Irregular depths of planting gives irregular ripening, and thus results in a poor grade of seed.

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NORTH DAKOTA AGRICULTURAL COLLEGE·

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FOR

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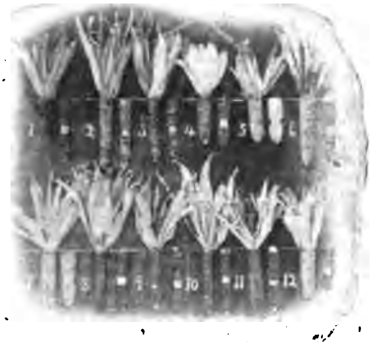
Bulletin No. 51.



CORN CULTURE.

By J. H. SHEPPERD
and A. M. TEN EYCK.

Any farmer, teacher or student in the state may have this Bulletin mailed to his address, free of charge, upon application.

FARGO, NORTH DAKOTA, U. S. A.
March 1902.

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CORN CULTURE IN NORTH DAKOTA.

A few farmers in nearly every county in the state have been growing corn successfully for years, and many others are being added to the list each season. More corn is grown in Cass County than in any other county in the state. The acreage planted in 1900 was 23,595 acres (more than was planted in the whole state in 1896), and the product, according to the report of the Commissioner of Agriculture, was 271,306 bushels. Richland County stood next to Cass with an acreage of 10,093 acres and a crop of 161,665 bushels. Something over 78,000 acres of corn were planted in the state in 1900 and the total crop was between seven and eight hundred thousand bushels. This does not include the fodder, which is of much value to the farmer. The acreage planted in the state in 1901 has not been published, but it was doubtless much larger than that of 1900. There is a great demand for seed corn this spring and the indications are that much corn will be planted in 1902.

This Station has carried on a series of experiments in growing corn for several seasons. The results of some of this work have been published in Bulletins Nos. 11, 23 and 39, and in the several annual reports of the Station. For the last two years no reports upon this subject have been made and it is the purpose of the present Bulletin to report the recent work and also to summarize the results of all experiments, and, so far as it seems advisable to discuss these results and draw general conclusions from the facts as they relate to corn growing in this state.

A TRIAL OF VARIETIES.

The Station has made a practice of testing varieties of corn recommended by farmers and seedmen as early, or adapted to North Dakota conditions. Bulletin No. 39 contains a complete report of the trial of varieties made in 1898, and something of a summary of the results of the trials up to that date.

TRIAL OF 1898.

Twenty-three varieties of corn were planted in the trial in 1898. The corn was planted rather late, May 27th and 28th, upon ground which was not well drained. The weather continued cold and wet, the seed did not germinate well, the corn made a slow growth in the early part of the season and none of it had reached full maturity when killed by frost, September 8th. The varieties having good yielding qualities which were nearest maturity at frost (ripe enough to save seed ears), are given in Table I, in the order of their earliness, for that particular season.

TABLE I.

Varieties of Corn Giving Largest Yields in 1898.

Bulletin No.	VARIETY	Yield per acre		
		Air dry fodder		Corn, ears
		tons	lbs.	bu.
*24	Gehu Flint	2	218	25.6
*25	Will's Dakota Flint	2	338	27.8
*28	Smut Nose Flint	3	633	17.8
*30	Mercer Flint	3	1250	......
*26	Northwestern Dent	2	1014	27.8
	Average	2	1497	24.7

*) These varieties were published in Bulletin No. 39 under their "record" numbers as follows: 24 equals 111, 25 equals 112, 28 equals 115, 30 equals 117 and 26 equals 113.

Mercer Flint corn gave the largest yield of fodder of any of the varieties tested in 1898. The yield of ears was not determined. Northwestern Dent and Will's Dakota produced the largest yield of ears. For the years 1894, 1895, and 1896, the average yield of ears of Mercer corn was 37½ bushels, 70 pounds to the bushel, and of fodder, 2 tons, 660 pounds per acre. The Mercer ripened during each of the above years as did also the Gehu and Northwestern Dent.

METHOD OF PLANTING.

In all of the variety trials reported upon the corn was planted with a two-horse hand drop corn planter, in rows three feet and eight inches apart, in hills three feet apart in the row, with from two to five kernels in a hill. The corn was rowed only one way and hence could be cultivated but one way. The depth of planting has usually been about three inches. The trials have always been made on fall-plowed land, which grew grain the previous year.

TRIAL OF 1899.

Twenty-seven varieties of corn were grown in the trial in 1899. Most of these were new seed secured direct from the various seed companies, being those sorts which were recommended as early and suited to Northwestern climate and conditions. All the varieties were planted May 22nd and 23rd, in the manner noted above. Two rows four hundred and twenty-eight feet long constituted a plot of each variety. The soil was in good condition, the weather was favorable and the corn came up well. The corn was harrowed once and cultivated four times during the season, which kept it fairly free from weeds, and a little work with the hoe put the field in good condition to "lay by" July 15th. All of the varieties were cut and shocked September 11th to 19th.

In the latter part of October the fodder was hauled in and weighed and the corn was husked and weighed. The fodder was not well cured at that time. Weighed samples were kept and weighed again later, when thoroughly cured. From these weights the percentage of loss was found and the actual yield of air dried fodder was calculated. The air dry weight of the corn (ears) was found in the same manner. These samples of corn and fodder lost from fifteen to forty-five per cent. in weight, showing that the fodder was far from dry when hauled from the field.

The record of the varieties tested in 1899 is given in Table II.

TABLE II.

Varieties of Corn—Crop of 1899.

Bulletin No.	VARIETY.	CLASS.	WHERE FROM.	Stage of maturity at frost, Sept. 12.	Average No. of stalks per hill.	Height of stalks.	Height of ears.	Yield per acre. †Air dry fodder		Yield per acre. ‡Corn in ear
						feet	in.	tons	lbs.	bu.
26	Northwestern Dent	red dent	Oscar H. Will & Co.	ripe	5 to 6	5	20	3	1199	48.6
34	Earliest Ripe	white dent	Salzer Seed Co.	"	4 to 5	5	16	2	345	37.5
40	Dutton	yellow flint	Minnesota Experiment Station	"	5	5½	24	3	1039	48.8
41	Will's Acme	mixed dent	Oscar H. Will & Co.	"	3	5	20	2	1208	34.2
38	Minnesota Small Dent	yellow dent	J. P. Chisholm, Englevale, N.D.	"	4 to 5	5¼	20	2	1567	45.1
42	Squaw	mixed flint	Minnesota Experiment Station	"	4	4	12	2	1833	43.2
43	Northrup, King & Co's Triumph	yellow flint	Northrup, King & Co	"	4 to 5	4½	18	3	167	37.6
44	N., K. & Co's Giant Fodder	white dent	" " "	silk	3 to 4	7½	48	3	1257	cobs
45	Improved Mercer	yellow flint	" " "	ripe	5 to 6	6	25	3	875	42.3
46	Gold Dollar Field	yellow flint	Sioux Falls Seed Co.	"	4 to 6	6	28	3	762	42.4
47	Squaw	mixed flint	Salzer Seed Co.	"	4 to 5	4½	14	3	639	39.5
48	South Dakota	yellow flint	" " "	dough to hard	6	6⅓	30	3	620	37.7
49	North Dakota	white flint	" " "	"	4 to 5	6	32	3	1099	42 4
50	Earliest Ripe	white dent	" " "	ripe	2 to 3	5	22	2	518	30.7
51	Angel of Midnight	yellow flint	" " "	dough to hard	6	6	28	4	148	41.1
52	King Phillip	red flint	L. L. May & Co	"	4 to 5	6½	28	3	1760	46.4
53	Extra Early Dakota Queen	yellow dent	" " "	dough	3 to 4	6½	24	2	1700	34.2
54	Pride of the North	yellow dent	" " "	"	3 to 4	7	36	2	1903	34.2
55	Pride of Canada	yellow flint	" " "	dough to hard	5 to 6	6¼	30	3	380	42.2
56	King of the Earliest	yellow dent	" " "	"	3 to 4	6½	36	3	278	35.2
57	Longfellow	yellow flint	" " "	"	5 to 6	5¾	24	3	1204	39.4
58	Will's Dakota	white flint	Oscar H. Will & Co	ripe	4 to 5	4½	16	2	1855	30.1
59	Gehu	yellow flint	" " " "	"	4 to 5	4½	18	3	648	43.4
60	Improved Northwestern Dent	calico dent	" " " "	milk	3	7	42	4	458	22.1
61	Early Sweet Fodder	dent	Farmer Seed Co.	nearly ripe	4 to 5	4	10	2	1150	20.5
62	Harman's Improved Aricaree	white flint	G. W. Harmon, Morton Co., N.D.	ripe	4	4½	12	2	1444	37.7
100	* North Dakota	yellow dent	N. Dak. Experiment Station	nearly ripe	5	4¾	24	2	1855	40.4

* A selection from Minnesota King, bred at this Station for eight years. † The word "fodder" as used in the tables and the discussions stands for both the stalks and the ears, i. e., the whole product. ‡ 70 lbs. per bushel.

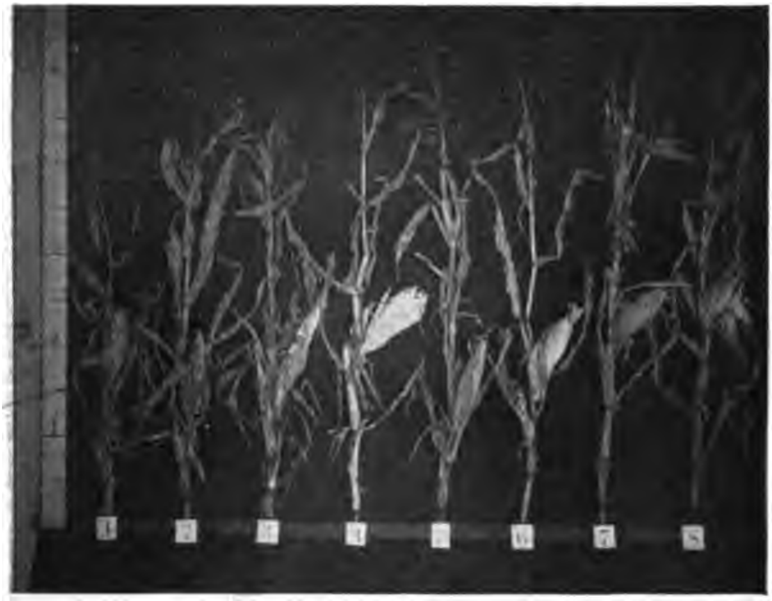

Fig. 1. Samples of Corn Fodder, crop of 1899. Varieties which ripen.

DESCRIPTION.

No.	Bulletin No.	Variety.
1	61	Early Sweet Fodder
2	47	Squaw Flint
3	62	Harman's Improved Aricaree
4	43	N. K. & Co.'s Triumph
5	58	Will's Dakota
6	59	Gehu Flint
7	50	Earliest Ripe Dent
8	26	Northwestern Dent

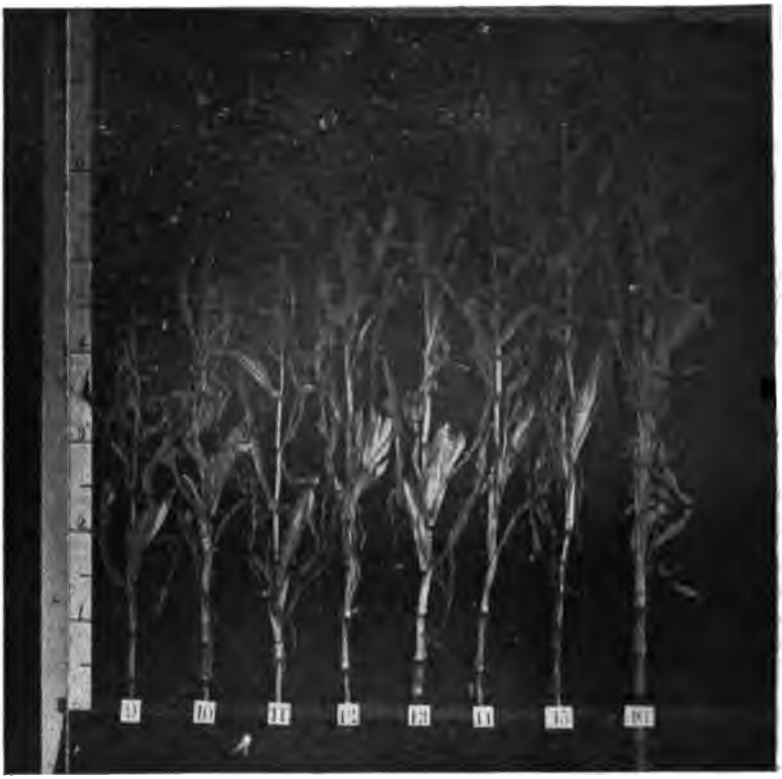

Fig. 2. Samples of Corn Fodder, Crop of 1899. Varieties which ripen, except No. 16.

DESCRIPTION.

No.	Bulletin No.	Variety.
9	100	Minnesota King
10	41	Will's Acme
11	40	Dutton Flint
12	46	Gold Dollar Flint
13	45	Improved Mercer
14	52	King Philip
15	48	South Dakota Flint
16	44	N. K. & Co.'s Giant Fodder

Out of the twenty-seven varieties tested in 1899, fourteen were ripe at frost, September 12th, one hundred and twelve days after planting. Most of the other varieties were in the "dough to hard" stage at that date—ripe enough to make good fodder. The season of 1899 was about an average season for corn.

The average yield of the fourteen varieties which ripened was 3 tons, 9 pounds of fodder per acre. The average yield of corn (ears) alone was 40.7 bushels.

The thirteen varieties which did not fully mature yielded on the average 3 tons, 387 pounds of fodder per acre. The varieties which ripened and gave the largest yields of fodder are given in Table III.

TABLE III.

Varieties of Corn Which Ripened and Which Gave the Largest Yields in 1899.

Bulletin No.	VARIETY	Yield per acre		
		Air dry fodder		Corn, ears
		tons	lbs.	bu.
36	Northwestern Dent	3	1199	48.6
40	Dutton Flint	3	1039	48.8
45	Improved Mercer	3	875	42.3
46	Gold Dollar	3	762	42.4
59	Gehu	3	648	43.4
	Average	3	905	45.1

The average yield of the best producing varieties was 3 tons, 905 pounds of fodder per acre, or 45.1 bushels of husked corn (70 pounds per bushel) and 3,748 pounds of stalks.

TRIAL OF 1900.

Twenty-three varieties of corn were planted in the trial of 1900. Fifteen of these, Nos. 66 to 80, were from new seed, which was secured from the several seed companies, eight were from seed selected from the Station crop of 1899. The corn was planted May 22nd on fall plowed land, which had been cultivated and kept free from weeds up to the time of planting. The months of May, June and July were very dry. The corn was planted too

TABLE V.

Varieties of Corn-Crop of 1900.

Bulletin No.	VARIETY.	CLASS.	WHERE FROM.	Stage of maturity at frost, Sept. 16.	Average No. of stalks per hill.	Height of stalks.	Height of ears.	Yield per acre. Air dry fodder.		Yield per acre. * Corn in ear.
						feet.	inches.	tons	lbs.	bu.
40	Dutton	flint	Minn. Ex Station	ripe Sept. 8	4 to 6	4⅛	10 to 18	2	189	40.9
41	Select Acme	light red dent	Oscar H. Will & Co	"	"	4⅛	12 to 20	2	1752	36.7
42	Squaw	mixed flint	Minn. Ex. Station	ripe Sept. 1	"	3⅛	1 to 12	2	1437	38.5
47	"	"	Salzer Seed Co.	ripe Sept. 8	"	3⅛ to 5	2 to 24	3	61	34.1
63	Cross bred	red dent	N. Dak. Ex Station	"	"	5	18 to 24	2	565	34.6
64	" "	light red dent	" " "	"	"	5	12 to 24	3	391	38.9
65	" "	yellow and white dimpl'd	" " "	ripe Sept. 1	"	4¾	12 to 20	2	1296	37.4
66	Will's Yellow Flint	flint	Oscar H. Will & Co.	⅜ hard	"	4¾	10 to 20	3	1220	39.5
67	Champion Dent	calico dent	" " "	milk and dough	3 to 4	6⅛ to 7	36	3	1630	36.8
68	Northwestern Dent	a redish dent	" " "	ripe Sept. 10	4	4¼	10 to 20	2	1186	39.5
69	Smut Nose	yellow flint	Northrup, King & Co.	mostly hard	4 to 6	4⅜	12 to 22	3	203	39.7
70	Squaw	mixed flint	" " "	ripe Sept 1	5 to 7	3¼	1 to 10	2	1972	38.0
71	North Dakota White Flint	flint	" " "	"	"	3⅓	2 to 12	2	1526	39.6
72	Longfellow	yellow flint	" " "	¾ hard	5 to 6	5 to 5⅛	12 to 24	3	683	41.5
73	Mercer	"	" " "	ripe	5	"	12 to 24	3	61	40.7
74	Triumph	"	" " "	"	"	"	12 to 24	2	1794	42.2
75	King Phillip	red flint	" " "	mostly ripe	"	5½	12 to 24	3	863	40.2
76	North Dakota Dent	yellow dent	" " "	dough to hard	2 to 3	6	24 to 36	1	1298	30.3
77	Will's Yellow and White Fodder	flint	Oscar H. Will & Co.	ripe Sept. 1	4 to 5	3⅓	1 to 10	2	11	35.7
78	Acme Fodder	reddish dent	" " "	ripe Sept. 7	"	3⅔	2 to 12	1	1835	32.9
79	Will's Dakota	white flint	" " "	ripe Sept. 1	"	3⅛	1 to 10	2	278	39.2
80	Gehu	yellow flint	" " "	"	"	3½	2 to 10	1	1926	34.8
100	† North Dakota	yellow dent	N. Dak. Ex. Station	ripe	5	4⅝	24	2	704	38.0

† A selection from Minnesota King, bred at this Station for eight years.

* 70 lbs. per bushel.

early to get the full benefit of the rains which came in August. The result was that most of the varieties made a short growth of stalks but a fair production of ears. The plots were kept clean and well cultivated. The corn was cut September 8th to 17th, and the fodder was hauled in November 7th and 8th. The fodder was not thoroughly cured at this date. Samples placed in a drying room until December 30th lost fifteen to twenty per cent. in weight. The yields both of corn and fodder given in Table IV were calculated from the air dry weights.

Seventeen out of the twenty-two varieties planted in 1900 were fully matured before the frost, September 16th. The other varieties were mostly ripe enough to make a good crop of hard ears. The period of growth from planting time until frost was one hundred and seventeen days.

In Table V are given the varieties which ripened and which gave the largest yields.

TABLE V.

Varieties Which Ripened and Which Gave the Largest Yields in 1900

Bulletin No.	VARIETY.	Yield per acre.		
		Air dry fodder		Corn, ears
		tons	lbs.	bushels
64	Cross-bred Dent	3	391	38.9
73	Mercer Flint	3	61	40.7
70	Squaw Flint	2	1972	38.0
74	Triumph Flint	2	1704	42.2
41	Selected Acme Dent	2	1752	36.7
71	North Dakota White Flint	2	1526	39.6
65	Crass-bred Dimpled Dent	2	1.96	37.4
68	Northwestern Dent	2	1186	39.5
	Average	2	1747	39.1

The average yield of the best producing early varieties in 1900 was 2 tons, 1,747 pounds of fodder, or 39.1 bushels of corn and 3,010 pounds of stalks per acre. The average yield of five of the best producing later varieties was 3 tons, 920 pounds of fodder per acre, which yielded 39.5 bushels of corn per acre. The season, because of the dry summer and long, wet fall, was especially favorable to the late maturing sorts. In the production of ears alone the five best producing varieties were as follows:

Triumph, 42.2 bushels; Longfellow, 41.5 bushels; Dutton, 40.9 bushels; Mercer, 40.7 bushels, and King Philip, 40.2 bushels.

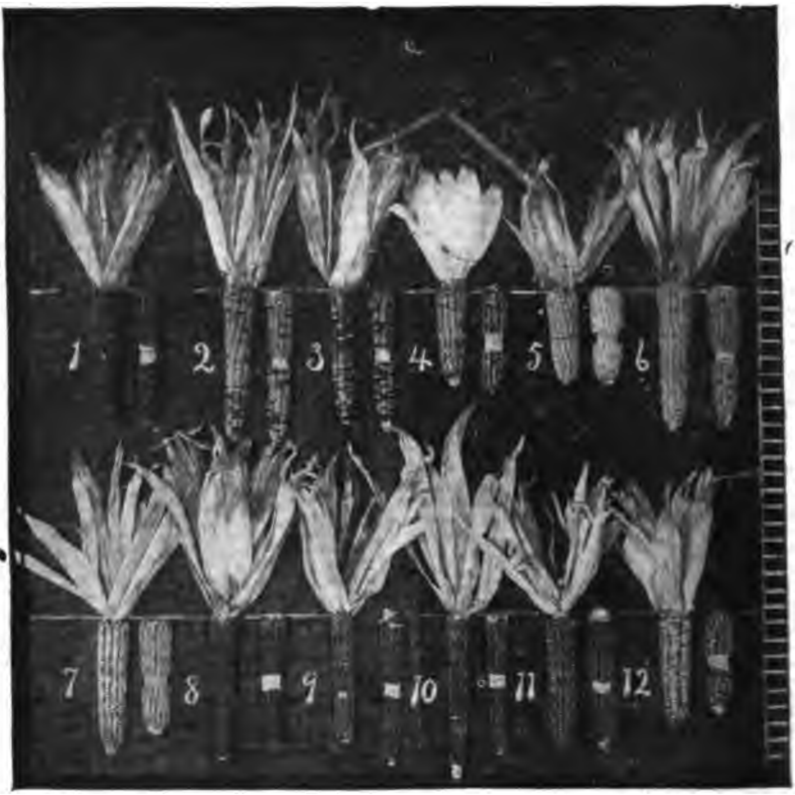

Fig. No. 3. Samples of Ears, Varieties of Corn which ripened in 1899 and 1900, arranged in the order of their earliness.

DESCRIPTION.

No.	Bulletin No.	Variety.
1	59	Gehu Flint
2	58	Will's Dakota
3	47	Squaw Flint
4	26	Northwestern Dent
5	50	Earliest Ripe
6	62	Harman's Improved Aricaree
7	41	Will's Acme
8	45	Improved Mercer
9	43	N. K. & Co.'s Triumph
10	46	Gold Dollar
11	40	Dutton Flint
12	100	Minnesota King

TRIAL OF 1901.

Forty-two varieties of corn were planted in the trial in 1901. These were all grown from new seed received direct from seedmen and farmers. The seed of the Station varieties was almost all destroyed in the fire which burned the College barn January 4th, 1901.

The ground upon which the trial was made in 1901 grew oats in 1900 and was fall plowed. The field was cultivated with the pulverizer and harrow several times before the planting, so that the soil was clean and in excellent condition at planting time. The corn was planted May 30th and 31st, about a week later than our usual date of planting. June 4th and 5th heavy rains fell followed by a light frost on the morning of June 7th. The varieties of corn were not up, but corn which had been planted early was injured slightly by the frost. On June 8th the soil was fit to work and the cornfield was harrowed. Heavy rains fell from June 9th to June 15th. The corn came up well and was a good stand on all plots. June 18th to 20th the field was harrowed twice with Halleck's weeder. The corn stood three to four inches high. The weeds had made a good start, but were fairly well subdued. The first cultivation was made with a Deere surface cultivator and was finished July 2nd, when the corn was six to eight inches high. Very heavy rains fell July 3rd, 4th and 5th, aggregating nearly five inches of water in the three days. The ground was filled with water, and for two days the field was flooded. The corn received a severe check, but good drainage kept it from being drowned out.

The corn was cultivated for the second time July 12th to 15th with the surface cultivator. The weeds were nearly all destroyed. The ground began to get hard and baked in places. It seemed necessary to stir the soil a little deeper, and the third cultivation, July 18th to 20th, was done with a six-shovel cultivator instead of the surface cultivator. With a very slight use of the hoe, the corn was "laid by" at this date. Later, August 3rd to 5th, because the ground was getting dry and baking, the corn was cultivated with a one-horse planet junior cultivator, once in a row.

All of the varieties were cut Sept. 16th to 17th with a McCormick corn binder and shocked a few days later. On November 2nd to 7th the fodder was hauled in and weighed and the corn was husked and weighed. Samples saved for drying showed a loss of twenty to sixty per cent. when thoroughly air dry.

Table VI gives the yields and other data for the trial.

TABLE VI.
Varieties of Corn-Crop of 1901.

Bulletin No.	VARIETY.	CLASS.	WHERE FROM.	Stage of maturity at frost, Sept. 18th.	Average No. of stalks per hill.	Height of stalks.	Height of ears.	Yield per acre.		
								Air dry fodder.		* Corn in ear.
						feet.	inches.	tons	lbs.	bu.
81	Early Golden Surprise	yellow dent	A. W. Livingston's Sons	milk & dough	2	7	42	1	1607	11.1
82	French's Squaw	flint	N. S. French, LaMoure, N.D.....	ripe	3	4	18	2	1224	35.2
83	Westwood Farm	white flint	Alex Campbell, Pembina, N.D......	"	3	3	6	1	1256	18.9
84	Queen of Nishua...............	yellow dent	Nishua Valley Seed Co.......	milk	2 to 3	7½	48	3	416	14.2
85	Earliest Ripe Fodder.........	white dent	Salzer Seed Co.	dough	"	5½	24	1	1990	16.8
86	Superior Fodder...	white dent	" "	silk & milk	2	10	54	1	1309	cobs
87	Brazilian Flour................	white	" "	silk	2 to 3	9½	60	2	1686	......
88	Yellow and White Fodder.	flint	Gscar H. Will & Co.................	ripe	"	3¾	6 to 12	2	40	21.3
89	Will's Acme Fodder..	yellow dent	" "	mostly hard	"	6½	36	3	131	35.1
90	Will's Orig. Northw. Dent.	red dent	" "	ripe	"	4¾	20	3	297	34.2
91	Triumph	yellow flint	" "	nearly ripe	"	5½	26	3	355	42.3
92	Will's Dakota.	white flint	" "	ripe	"	3½	6	2	551	26.5
93	Pride of the North.......	yellow dent	" "	dough & hard	"	6½	36	2	249	22.2
94	Elephant Fodder...............	"	Northrup, King & Co......	milk to dough	"	8	42	2	749	22.2
95	Smut Nose	yellow flint	" "	dough to hard	3	6	30	3	187	34.4
96	N Dak. White Flint.........	white flint	" "	ripe	3	4	10	2	1396	24.9
97	Longfellow	yellow flint	" "	dough to hard	2 to 3	6½	30	2	923	25.4
98	King Phillip............	red flint	" "	"	"	6½	30	3	117	34.5
99	Early Sweet Fodder	sweet	" "	milk to dough	3	7	32	1	1256	10.3
101	New White Fodder	white dent	" "	"	2 to 3	8	48	3	154	15.5
102	Minnesota No. 13..............	yellow dent	" "	dough to hard	"	7	42	2	1123	29.8
103	Minnesota King..	"	" "	"	"	6½	30	1	1715	26.8
104	Northwestern Dent...........	red dent	" "	mostly ripe	"	6½	32	3	608	33.5
105	Mercer	yellow flint	" "	ripe	3 to 4	6½	26	2	1898	38.0
106	Early Rustler White Dent.	white dent	" "	dough to hard	2 to 3	7	36	4	518	27.7
107	Early Sweet Fodde...........	sweet	" "	milk to dough	3	7½	36	1	1633	41.9
108	Giant Fodder......................	white dent	" "	silk to milk	2 to 3	9½	60	2	832	......
109	Early Giant	"	Wm. Rennie	dough to hard	"	8	44	3	589	25.3

110	Mammoth Cuban	yellow dent	Wm. Rennie	milk to dough	2 to 3	8½	48	3	458	25.2
111	Northern Prolific	yellow flint	" "	dough to hard	3	7	32	2	1601	41.4
112	Compton's Early	"	" "	mostly hard	3	6½	30	3	1690	46.6
113	Improved Leaming	yellow dent	" "	milk to dough	2 to 3	8½	44	4	1770	31.2
114	S. D. Early White Dent	white dent	G. N. Dawson, Havana, N. D.	mostly ripe	"	6	28	3	760	51.4
115	Smut Nose Dent	red dent	" " " "	"	3	6¼	26	4	824	51.2
116	Dawson's Cross-bred Dent	"	" " " "	"	2 to 3	6	28	3	744	63 6
117	Fey's Yellow Dent	yellow dent	John J. Fey, Power, N. D.	milk to dough	"	8	48	3	151	33.7
118	Sanford Flint	flint	J. W. Boeing, Gr. Forks, N. D.	dough	3	7½	38	3	801	36.5
119	Golden Dent	yellow dent	Walter Russell, Fargo, N. D	ripe	3 to 4	6	30	1	1882	45.5
1.0	Dakota Queen	"	Fargo Lime & Fuel Co	milk to dough	2 to 3	8	42	3	......	27.6
100	† North Dakota	"	N. Dak. Ex. Station	about ripe	"	5	24 to 30	2	313	29.7
40	Dutton	yellow flint	" " "	ripe	3	5	15	2	596	33.9

† A selection from Minnesota King, bred at this Station for eight years.

* 70 lbs. per bushel.

The yields given are the air dry weights both of the fodder and the ears. When the fodder was hauled and the corn husked, samples were taken for drying. These samples were carefully dried in an oven at 110 degrees C., until they were chemically dry. The air dry weights were calculated from the chemically dry weights.

An average sample of fodder which was allowed to remain in a dry room until it was thoroughly air dry, when made chemically dry lost 14.1 per cent. on the chemically dry weight. Several samples of ears treated in the same manner lost on the average 12.8 per cent. on the chemically dry weight. Thus the chemically dry weight of the fodder multiplied by 114.1 per cent. equals the air dry weight, and the chemically dry weight of the ears multiplied by 112.8 per cent. equals the air dry weight. To find the actual dry matter divide the yield of air dry fodder by 114.1 per cent. and the yield of ears by 112.8 per cent.

Fifteen out of the forty-one varieties planted in 1901 were ripe or "nearly ripe" when cut September 16th, two days before the first frost. The period from planting until frost was one hundred and ten days. The early part of the season was too wet and cold for corn to make much growth on the flat lands of the Station farm, but the latter part of the season was a period of very rapid growth, resulting in a large production of stalks and a good crop of corn from those varieties which were able to mature ears.

The best producing varieties which ripen are given in Table VII, in the order of their yields of corn.

TABLE VII.

Varieties of Corn which matured and gave the largest yields of Fodder and Ears in 1901.

Bulletin No.	VARIETY.	Yield per acre.			Loss in weight of fodder after hauling.
		Air dry fodder.		Corn, ears.	
		tons	lbs.	bu.	per ct.
116	Dawson's Cross-bred Dent	3	744	63.6	30.9
114	South Dakota Early White Dent	3	760	51.4	24.2
115	Smut Nose Dent	4	824	51.2	22.5
112	Compton's Early Flint	3	1690	46.6	29.4
119	Golden Dent	3	1882	45.6	22.6
91	Triumph Flint	3	355	42.3	35.8
105	Mercer Flint	2	1898	38.0	32.2
90	Will's Original Northwest Dent	3	297	34.2	20.5
	Average	3	1056	46.6	27.3

The seed of the three varieties which gave the largest yields of ears was sent to the Station by G. N. Dawson, Havana, North Dakota. These are excellent producing varieties both of fodder and ears. They did not fully mature last season, but probably will do so in a more favorable season.

Golden Dent which ranked fifth in the production of ears and second in the production of fodder is a variety of corn which, according to James Holes of Fargo, has been grown in North Dakota and in this vicinity for fifteen years. The Station secured seed from Walter Russell of Fargo. This is an early variety of corn. The ears are small, but well covered with small deep set kernels. The cobs are small and the ears will shell a high percentage of kernels per bushel.

The proportion of corn to cob was determined for two varieties, as follows:

Golden Dent, 86.7 per cent. shelled corn, 13.3 per cent cob; North Dakota No. 100, 78.8 per cent shelled corn, 21.2 per cent. cob.

In the above trial thirty-five selected ears of each variety were shelled and the ears used were thoroughly air dry. The thirty-five ears of Golden Dent gave 9.65 lbs of shelled corn and 1.6 lbs of cobs. The thirtyfive ears of North Dakota No. 100 yielded 9.3 lbs of shelled corn and 2.5 lbs of cobs. Per 100 lbs of ears, the Golden Dent gave 7.9 lbs more shelled corn than the North Dakota No. 100.

Compton's Early Flint corn yielded more fodder and more ears than any other flint variety tested in 1901. This variety is, however, a trifle late to be placed in the class with Mercer and Triumph. The last named varieties are early maturing and yield a good quality of corn.

Northwestern Dent is one of the best producing sorts. This variety is well known throughout the state and is a good average producer of both fodder and ears.

Other varieties of corn which produced large yields of fodder but did not mature so good a crop of ears as the ones just described are given in Table VIII.

TABLE VIII.

Best Yielding Varieties of Corn which did not fully mature in 1901.

Bulletin No.	VARIETY.	Yield per acre. Air dry fodder. tons	lbs.	Yield per acre. Corn, ears. bu.	Loss in weight of fodder after hauling. per ct.
113	Improved Leaming	4	1770	31.2	33.3
118	Sanford Flint	3	801	36.5	41.0
109	Early Giant	3	584	25.3	38.7
110	Mammoth Cuban	3	458	25.2	48.7
84	Queen of Nishua	3	416	14.2	38.7
95	Smut Nose Flint	3	187	34.4	32.7
101	New White Fodder	3	154	15.5	46.0
117	Fey's Yellow Dent	3	151	33.7	54.7
89	Will's Acme Fodder	3	131	35.1	31.2
98	King Phillip	3	117	34.5	29.1
	Average	3	677	28.6	39.4

By comparing Tables VII and VIII, it will be seen that the largest average production of both fodder and ears was given by the varieties which matured.

The last column in each table gives the percentage of loss in the weight of the fodder, comparing its weight when hauled from the field to its weight when thoroughly air dry. It will be observed that the fodder which was least mature when cut contained on the average twelve per cent. more water when it was hauled from the field than did the mature fodder. The late corn was greener and contained more water when cut than the early corn hence it failed to cure as well as the earlier and riper corn. None of the fodder was dry enough to stack with safety when it was hauled.

THICKNESS OF PLANTING CORN.

Experiments in thickness of planting corn have been carried on for several seasons. The methods of planting and the results of the experiments in this line in 1898 are fully discussed in Bulletin No. 39. The plan of the experiments and the treatment and cultivation of the crop has been similar each year so that a detailed account of the work of each season will not be necessary in this discussion.

In these trials the corn was planted each year during the last week in May and the fodder was cut during the second week in September. The yield of air dry fodder and of ears was determined in the manner already described under varieties. North Dakota No. 100 was the variety grown in all these trials, except in 1901, when Dakota Queen No. 120 was used.

BROADCASTING VERSUS DRILLING AND PLANTING IN HILLS.

In this experiment, the corn seeded broadcast was sown by hand at a medium rate and covered with the harrow. The drilled corn was planted with a shoe chain drill. The drill was set to sow two and one-half bushels of oats per acre. This dropped the kernels six to ten inches apart in the drill row. In order to get the required distance between the drill rows, the extra grain cups were plugged. The corn planted in hills was rowed only one way. The implement used for planting was a two-horse hand drop corn planter, set to drop four to six kernels in a hill. The hills averaged about eighteen inches apart in the row. The twenty-two inch rows were made by doubling back with the planter on the forty-four inch rows. The corn sown broadcast and that planted in six and twelve inch drills was harrowed after planting, but received no further cultivation. The other plots were cultivated either with a single or double cultivator and were kept free from weeds.

Table IX gives the record of the yields by the several methods of planting, covering a period of four years.

TABLE IX.

Broadcasting Corn Versus Drilling and Planting in Hills.

Plot No.	HOW PLANTED.	Height of stalks	Yield per acre, 1898.			Yield per acre 1899.			Yield per acre, 1900.			Yield per acre, 1901.		Yield per acre, average.		
			Air dry fodder		* Corn in ear.	Air dry fodder.		* Corn in ear	Air dry fodder.		* Corn in ear.	Air dry fodder.		Air dry fodder.		* Corn in ear.
		feet.	tons	lbs	bu.	tons	lbs.	bu.	tons	lbs.	bu	tons	lbs.	tons	lbs.	bu.
1	Sown broadcast	3	3	1251	....	2	1479	....	....	....	....	....	....	....	....	....
2	Drills, 6 inches apart	3	4	792	....	3	522	....	4	1000	9 6	4	170	4	121	....
3	Drills, 12 inches apart	3¼	4	244	....	2	1382	....	4	348	8 9	3	1800	3	1444	....
4	Drills, 18 inches apart	4	5	614	25.7	3	73	10 8	3	1394	32.9	3	612	3	1673	23.1
5	Drills, 24 inches apart	4⅛	4	1417	27.6	2	1833	20.5	3	1910	38.9	3	327	3	1374	29 0
6	Drills, 30 inches apart	4⅛	4	1416	29.3	3	333	29.1	3	1071	41 8	2	1972	3	11 8	34.4
7	Drills, 36 inches apart	4⅛	3	1276	27 2	3	305	33.4	3	1 86	40 7	3	368	3	7 4	33 7
8	Drills, 42 inches apart	4¾	3	1274	27.0	2	1228	37.8	2	1518	33.2	3	127	3	62	3 .7
9	Hills, rows 44 inches apart	4¾	....	....	....	3	606	41 1	2	207	31 2	3	93	2	1 35	35 1
10	Hills, rows 22 inches apart	4½	....	....	....	4	987	45.9	4	315	....	4	208	4	501	....

* 70 lbs. per bushel.

As an average for three trials, the largest yield of fodder was obtained from the plots planted in rows twenty-two inches apart, viz., double-rowed with the corn planter. The ears were mostly nubbins, but the stalks were leafy and not too coarse to feed whole. Thick and close planting causes an earlier maturity and allows earlier harvesting and stacking. Corn planted in drill rows has yielded more fodder on the average than the corn planted in hills and rows forty-four inches apart, but the largest yield of ears was produced by the corn planted in hills.

Corn sown broadcast has not yielded so well as that sown in drills. Of the latter, the corn sown in drills six inches apart has given the largest yield of fodder as an average for the four trials. The amount of ears and consequent richness of the fodder increased as the distance between the drill rows was increased.

The shorter and finer quality of the stalks grown by broadcasting or by the close drilling of corn makes them better to feed whole. But there are advantages in growing corn fodder in rows far enough apart to allow of cultivation, as corn forms a splendid preparatory crop for wheat when the corn is kept thoroughly cultivated. The cultivation destroys weeds and saves the soil moisture, giving ample return for the extra labor expended in the increase of succeeding wheat crops. It was noted in our fields in 1899 that wheat was poorer on ground which had grown sowed corn in 1898 than it was upon adjacent land where the corn had been cultivated. No records of the yields were made in that instance, but the difference in crop was apparent to the eye. In the dry season of 1900 the difference in the crop upon the several plots which had been planted to corn the year previous was very marked. Where the corn was cultivated in 1899, yields of twenty to twenty-five bushels per acre were obtained, while on the land which grew sowed corn in 1899, the yield was only twelve to thirteen bushels per acre, or only about half as much crop as was secured from the land upon which the corn was cultivated the year previous.

THICKNESS OF PLANTING IN DRILL ROWS.

In this experiment the corn was planted by hand, two kernels in a hill, at the required distance apart, and later thinned to one stalk in a hill. The experiment was not continued in 1900 and 1901. Table X gives the results of two trials, 1898 and 1899.

TABLE X.

Thickness of Planting Corn in Drill Rows.

Plot No.	How planted.	Height of stalks.	Yield per acre, 1898. Air dry fodder.		Yield per acre, 1898. * Corn in ear.	Yield per acre, 1899. Air dry fodder.		Yield per acre, 1899. * Corn in ear.	Yield per acre, average. Air dry fodder.		Yield per acre, average. * Corn in ear.
		feet	tons	lbs.	bu.	tons	lbs.	bu	tons	lbs	bu.
1	3½ ft. by 6 in.....	4⅛	4	0	34.5	3	650	43.6	3	1325	39.1
2	" " 10 in......	4⅛	3	153	26.2	2	1232	42.7	2	1603	34.5
3	" " 12 in......	4⅛	2	1903	24.8	2	1560	42.2	2	1732	33.5
4	" " 14 in.....	4¾	2	555	21.9	2	978	35.4	2	1267	28.7
5	" " 16 in......	4¾	1	1912	18.7	2	1572	34.7	2	742	26.7
6	" " 18 in....	4¾	1	1970	16.6	2	70	33.3	2	20	25.6
7	" " 24 in .	4⅝	1	969	13.7	1	1618	24.7	1	1294	19.2
8	" " 36 in......	4⅝	1	339	9.4	1	1327	20.4	1	833	14.9

* 70 lbs. per bushel.

The largest yield both of fodder and of ears was secured each season from the plots in which the stalks were six inches apart in the drill row. The growth of the stalks in height was not affected much by the thickness of planting, and the stage of maturity at harvest was practically the same whether the stalks were six or thirty-six inches apart in the drill row. There were more nubbins and the quality of the corn was not so good from the thick planting as from the thinner planting. The difference in the quality of the corn (ears), however, may vary with the season. In 1899 there was not much difference in the quality of corn grown by the different methods. For fodder purposes the thicker planting may be recommended.

NUMBER OF STALKS IN A HILL.

In this experiment the corn was planted by hand in hills three and one-half feet by three feet apart, in checks making rows both ways.

Table XI gives the results of the trial in 1898 and 1899, and also the average yields for the two years.

TABLE XI.

Number of Stalks in a Hill.

Plot No.	Number of stalks in a hill.	Height of stalks.	Yield per acre, 1898.			Yield per acre, 1899.			Yield per acre, average.		
			Cured fodder.		* Corn in ear.	Cured fodder.		* Corn in ear.	Cured fodder.		* Corn in ear.
		feet	tons	lbs.	bu.	tons	lbs.	bu.	tons	lbs.	bu.
1	One	4¾	1	386	9.4	1	1861	21.5	1	1124	15.4
2	Two	4¾	1	1574	19.2	2	396	33.2	1	1985	26.1
3	Three	4¾	2	258	22.6	2	1201	39.3	2	730	31.0
4	Four	4¾	2	1417	23.8	2	1407	40.0	2	1412	31.9
5	Five	4¾	2	688	23.8	2	1855	40.4	2	1272	32.1
6	Six	4¾	2	1417	26.9	3	589	42.2	3	3	34.6

* 70 lbs. per bushel.

Corn planted six kernels in a hill has given the largest yield both of fodder and ears. The number of stalks in a hill, where the range was from three to six, did not greatly affect the yield of either the fodder or the ears. Little difference was observed in the height of the stalks or the stage of maturity at harvest. Five to six stalks in a hill gave a finer stemmed fodder, but smaller and poorer ears than three to four stalks per hill. The yield of fodder and ears was not so great when the corn was planted six kernels in a hill, with the hills three feet apart in a row, as it was when the corn was planted in drill rows three and one-half feet apart, with single stalks six inches apart in the drill. From Table VIII it would appear that for large yields of fodder, planting small hills eighteen inches apart in the row was perferable to planting large hills three feet apart in the row. However, it is easier and more convenient to cultivate and keep clean corn which is planted in rows both ways, and since the purpose of growing corn in North Dakota is not only to secure large yields of fodder and ears, but also to rotate and clean the land and prepare the ground for wheat and flax, the method of planting in hills and rows both ways is as a rule to be recommended. Often, however, farmers who wish to plant a few acres of corn for fodder do not have a corn planter. In such a case the ordinary grain drill may be successfully used, and by stopping up part of the grain cups, the space between the rows of corn may be readily adjusted. Corn planted in this way requires careful cultivation to keep it clean, but trials at this Station show that it can be kept clean by proper cultivation, and a very slight use of the hoe, perhaps, at the critical time, just before the last cultivation.

DEPTH OF PLANTING CORN.

In this trial the corn was planted by hand at the required depth. The rows were three and one-half feet apart with hills three feet apart in the row and three kernels in a hill. The trial has always been made on fall plowed land. This experiment was discontinued in 1900. The results given in Table XII are for the two seasons, 1898 and 1899.

TABLE XII.

Depth of Planting Corn.

Plot No.	Depth planted.	Average height of stalks.	Yield per acre, crop of 1898.			Yield per acre, crop of 1899.			Yield per acre, average.		
			Air dry fodder.		Corn in ear.	Air dry fodder.		Corn in ear.	Air dry fodder.		* Corn in ear.
	In.	feet	ton	lbs.	bu.	ton	lbs.	bu.	ton	lbs.	bu.
1	2	4¾	1	1750	21.7	2	1653	*45.0	2	702	33.4
2	3	4¾	1	1958	21.4	2	1850	45.9	2	004	33.7
3	4	4¾	1	1750	17.7	3	614	41.3	2	1282	29.2
4	5	4¾	1	1229	14.8	2	1998	42.4	2	614	28 6
5	6	4⅜	0	1771	9.3	2	1484	37.0	1	1628	23.2
6	7	4⅜	0	1667	6 4	2	393	21.4	1	1030	17.9

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* 70 lbs per bushel.

Corn planted two to four inches deep has given the best results. As an average for the two trials, corn planted three inches deep has given the largest yield of ears, also the largest yield of fodder, in 1898. In 1899, the largest yield of fodder was given by planting four inches deep, and the average crop of fodder for the three seasons favors planting four inches deep. The results on the whole favor shallow rather than deep planting.

The corn planted six and seven inches deep did not make a stand in 1898. In 1899, the stand was fair but not so good as that of tne shallow planted corn. Not much difference was noticed in the stand of corn planted less than six inches deep. It was noted each season that the corn planted two to four inches deep, was slightly earlier in maturing and produced a ranker and more leafy fodder and larger and better developed ears, than the deeper planted corn.

When the ground is wet and cold, corn should be planted shallow. If the soil is dry or in good condition and warm, it is advisable to plant deeper. Plant shallow on heavy clay land and deeper on light or sandy soils. If it is the purpose to harrow corn after it comes up, plant a little deep rather than too shallow, especially if the soil is mellow. The deep planted corn will not be injured so much by the harrowing as the shallow planted corn. This rule also holds for potatoes and for wheat, when they are to be harrowed after they come up.

DATE OF PLANTING CORN.

A complete experiment in planting fodder corn at different dates has been carried on for one season. In 1901 two plots of corn were planted each week, beginning with the 18th of May and ending with July 2nd. One plot was planted in drills six inches apart, the other was planted in drill rows three and one-half feet apart. The planting was done with a grain drill which was set to sow two and one-half bushels of oats per acre. The six inch drills received no cultivation except harrowing once after sowing and once after the corn was up. The corn planted in drill rows, two and one-half feet apart, was harrowed and cultivated and kept free from weeds.

The experiment was carried on partly upon fall and partly upon early spring plowed land. The plots planted after June 8th were on the spring plowing, the others were on the fall plowing. The ground was put into good condition and thoroughly cleaned of weeds just before the planting at each date. The variety of corn used in this trial was Dakota Queen fodder corn, a medium late variety which does not fully mature but makes an excellent fodder. The corn on all plots ~~was~~ cut September 7th to 9th, weighed green and put into the silo. A sample from each plot was saved and dried, and from the percentage lost in drying, the yield of air dry fodder was calculated.

The results of this trial are given in Table XIII.

TABLE XIII.

Different Dates of Planting Corn—Crop of 1901.

Plot No.	DATE OF PLANTING.	Stand	Height of stalks.	Stage of maturity at harvest.	Quality of the fodder.	Yield per acre. Green fodder.		Yield per acre. Air dry fodder.		Water in green fodder.
	Six inch drills.									
			feet			ton	lbs.	ton	lbs.	per ct
1	May 18th	very thick	4	a few ears mature	fair	13	1358	3	785	78.2
2	May 25th	"	5	no ears about mature	very fair	19	200	4	614	78.1
3	June 1st	"	4	"	"	20	247	4	170	73.7
4	June 8th	"	5	"	"	21	941	4	1701	80.2
5	June 15th	"	4 to 6	some silk	"	10	1257	3	1117	81.2
6	June 22nd	"	4 to 5	tasseled	fair	22	772	4	1044	82.3
7	July 2nd	thick	3 to 4	tasseling	poor	19	181	3	147	85.9
	Forty-two inch drills.									
1	May 18th	good	6½	dough to hard	fair	10	1950	2	1492	71.1
2	May 25th	thick	7	dough	good	12	1555	2	1141	76.2
3	June 1st	"	7½	milk and dough	very good	16	79	3	127	77.7
4	June 8th	"	7	milk	"	16	277	3	445	82.8
5	June 15th	"	7 to 8	silk and milk	"	14	1206	2	1037	83.1
6	June 22nd	"	7 to 8	silk	"	14	254	3	103	82.1
7	July 2nd	good	....	tasseled	fair	11	1112	1	490	90.8

A sample of fodder which was already thoroughly air dry, when dried in an oven at 110 degrees C. lost 14.1 per cent. on the chemically dry weight. The yields of air dry fodder were calculated from the weights of the chemically dry fodder by multiplying the chemically dry weight by 114.1 per cent. Thus the yields given are exactly comparable to each other in regard to the actual amount of dry matter produced on each plot. If the yields given be divided by 114.1 per cent. the result will be the actual dry matter produced on an acre.

The corn planted in six-inch drills has given the largest yield for each date of planting, as follows:

Average yield of air dry fodder, 6 in. drills—3 tons, 1954 lbs.

Average yield of air dry fodder, 42 in. drills—2 tons, 1334 lbs.

The thick planted corn which was not cultivated produced on the average 1 ton, 620 pounds more per acre than the corn which was planted in drills and cultivated.

The largest yield of air dry fodder in each trial was produced by the corn planted June 8th. It will be noticed that there is a falling off in the yields in both trials for the corn planted June 15th and a gain for the June 22nd planting. The reason for this is not clear. The corn planted July 2nd failed to make a full growth and fell off in yield of air dry fodder, but the yield of green fodder was comparatively large.

The early planted corn did not yield so much fodder as that planted later. No yield of ears was taken, but it was apparent that the proportion of ears to stalks was much greater in the early planted corn. Late planting gives a greater yield of stalks with a smaller production of ears.

As will be noticed from the last column in Table XIII there was a large difference in the water content of the green fodder when it was harvested. The percentage of water in the green fodder, with only two variations, increased gradually with the date of planting, being least in the early planted corn and greatest in the late planted corn. The corn planted July 2nd, in forty-two inch drills, contained ninety per cent. of water when cut—twenty per cent. more than the corn planted May 18th. There was not so great a difference in the water content of the corn planted in six-inch drills as there was in the corn which was planted in forty-two inch drills and cultivated.

COMPOSITION OF CORN FODDER AT DIFFERENT STAGES OF GROWTH.

The following study was made by Professor E. F. Ladd of this Station while he was connected with the New York Station.*

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* New York Station Report 1889.

TABLE XIV.

Water and Dry Matter in a Corn Crop at Different Periods after Tasseling.

Date of Cutting.	Stage of Growth.	Green corn, per acre.	Water, per acre.	Dry matter, per acre.
		tons	tons	tons
July 30............... ..	Fully tasseled	9.0	8.2	.8
August 9	Fully silked	12 9	11.3	1.5
August 21	Kernels watery to full milk	16.3	14.0	2.3
September 7	Kernels glazing........................	16.1	12.5	3.6
September 23	Ripe........	14.2	10.2	4.0

From the above trial, it will be seen that corn which was silked had practically twice as much dry material per acre as it had when it was tasseled.

When in the milk it contained almost three times as much dry material as when in the tassel. When glazing it had more than four times as much dry matter per acre as it had when it was tasseled.

TABLE XV.

Increase of Starch and Sugar in Ripening Corn.

DATE.	Stage of Maturity.	Glucose, per acre.	Sucrose, per acre.	Starch, per acre.
		lbs.	lbs.	lbs.
July 30.	Tasseled.	58.3	9.1	122.2
August 9	Silked	300.4	110.8	491.3
August 21	In milk..................................	665 0	121.0	706.7
September 7	Glazed	7.0 2	95 1	1735.0
September 23	Ripe	538.4	148.9	2852.9

Professor Ladd says: "The total starch per acre increased more than twenty-three times between the tasseling of corn and harvesting, a period of fifty-five days."

Results of thirteen trials, according to Jordan's The Feeding of Animals, † show that corn cut before the glazing stage contained as fodder 65¾ lbs of digestible food per hundred lbs dry matter; as ensilage 67 1-3 lbs of digestible food per hundred lbs dry matter.

Results of ten trials show that corn cut in or after the glazing stage contained as fodder 70¾ lbs of digestible food per hundred lbs. of dry matter, as ensilage 73 2-3 lbs of digestible food per hundred lbs of dry matter.

The above data indicate that the feeding value of corn fodder cut in the immature stages is not so great as that of fodder which is allowed to become nearly mature before cutting. On the other hand, although its absolute feeding value may be less, the corn which is cut green, when dry, is said to be more palatable to stock than the fodder which is allowed to mature before cutting, and will probably be eaten more closely on that account.

A study of the composition and feeding value of corn fodder grown at this Station and cut at different stages of maturity is now in progress and will be reported upon at some future time.

LARGE YIELDS OF FODDER BY LATE PLANTING.

In the season of 1900 twenty acres of fodder corn, (common Iowa corn, bought on the market for feed) was planted in eighteen inch drills, July 10th, on land which had been fall plowed and kept cultivated up to the time of planting. This corn was harrowed several times, but received no other cultivation. On September 5th measured areas from this field were harvested and weighed and the yield was calculated to be twenty-one and one-half tons of green fodder per acre, equivalent to four tons of air dry fodder. The corn stood seven to eight feet in height and was just beginning to silk. It had made this growth in fifty-seven days.

Late planting allows opportunity for cultivating and cleaning the land before planting, making less cultivation necessary after planting and assuring a clean field for the following crop of wheat or flax. On the other hand the corn planted early will be nearer ripe when harvested and will cure better and in a shorter time than the greener, late planted corn. In the stacking and storing of fodder this is a point which must be considered.

† The Feeding of Animals, page 212.

In 1898 a medium late variety of corn planted at three different dates in rows three feet and eight inches apart and in hills three feet apart in the row yielded as follows:

Corn planted May 24th gave 12,206 pounds of green fodder per acre—equal to 3,958 pounds of air dry fodder which yielded 1,500 pounds of ears. Corn planted May 31st yielded 11,060 pounds of green fodder per acre, equal to 4,423 pounds of air dry fodder which yielded 1,406 pounds of ears. Corn planted June 15th yielded 13,141 pounds of green fodder per acre, equal to 4,445 pounds of air dry fodder which yielded 890 pounds of ears. The height of stalks was about the same for each plot. The stage of maturity at cutting was "dough to hard", "dough" and "milk to dough", in the order of the dates of planting. In this experiment the largest yield of ears was produced by the earliest planted corn, but the largest yield of fodder was given by the late planted corn.

CULTIVATION EXPERIMENTS WITH CORN.

Experiments in cultivation have been carried on for two seasons, 1898 and 1899. The corn was planted in rows three feet and eight inches apart and in hills three feet apart in the row, May 28th in 1898 and May 23rd in 1899. The corn was all harrowed alike after planting. The shallow cultivation was done with a single-horse, small-shovel cultivator which stirred the ground one and one-half to two inches deep. The deep cultivation was done with an ordinary riding corn cultivator which loosened the soil to the depth of four to five inches. All plots were cultivated an equal number of times. Minnesota King corn No. 100 was used in these trials. The yields and other data are given in Table XVI.

TABLE XVI.

Results of Cultivation Experiments with Corn, 1898 and 1899.

Plot No.	METHOD OF CULTIVATION.	Height of stalks.	Comparative stage of maturity.	Yield per acre.		
				Green fodder.	* Air dry fodder.	Ears.
	Crop of 1898.					
		feet		lbs.	lbs.	lbs.
1	Shallow	5¼	dough to hard	11837	4685	1633
2	Deep	5¼	less mature	12882	4122	1664
3	Shallow early, deep late	5⅛	like No. 2	12882	4122	1967
4	Deep early, shallow late.	5½	like No. 1	11642	4657	1598
	Crop of 1899.					
1	Shallow	4¾	ripest	....	6400	2746
2	Deep	4¾	nearly ripe	....	5463	2835
3	Shallow early, deep late	5	" "	....	5409	2835
4	Deep early, shallow late	5	" "	....	5237	2253

* Includes the stalks and ears.

As an average for the two trials, shallow cultivation gave 745 pounds more fodder but 60 pounds less ears per acre than deep cultivation. Cultivating shallow early in the season and deep late in the season, viz., the last cultivation, seems to have given more favorable results than the continuous deep cultivation or the deep cultivation early, followed by shallow cultivation the last time.

It is now generally conceded that corn should be cultivated shallow. The results of experiments reported from several states usually favor shallow cultivation. The roots of corn grow naturally within a few inches of the surface of the soil and it is evident that too deep cultivation will injure them, yet it is necessary to cultivate the soil deep enough to produce a mulch of mellow soil of sufficient thickness to retain the soil moisture. The mulch of mellow soil also acts as a cover to regulate and retain the heat in the surface soil. This is a very important factor in corn culture in North Dakota.

HARROWING CORN.

There is no cheaper method of destroying young weeds than by the proper use of a harrow. The ground which is to be planted to corn, if fall plowed, should be pulverized and harrowed several times, to thoroughly subdue the early weeds, or if spring plowing is preferred, the land should be plowed early and harrowed at intervals, several times before planting. In this way the ground is put into good condition to conserve the soil moisture and two or three crops of young weeds will be destroyed.

The corn should be harrowed after planting, before it comes up. A week after the corn is up, it may be harrowed again and it is usually satisfactory to keep the harrow going until the corn is four to six inches high. If the spring tooth weeder is used instead of the harrow, corn may be harrowed until it is eight to ten inches high. By means of this early cultivation the corn has been kept thoroughly clean in the hill and the crop needs only two or three cultivations with the cultivator, when it will be ready to "lay by" clean, and with the soil in excellent condition.

It is well to plant corn a little thicker than it is really desirable to have it grow, so as to allow for the destruction and the non-germination of some seed, and also for the pulling out and covering up of some of the small stalks by the harrowing and the early cultivation. If the thickness desired is three to four stalks per hill, then the corn should be planted four to five kernels per hill, even if the seed is considered good.

A STUDY OF THE ROOT DEVELOPMENT.

In Bulletins Nos. 36 and 43 of this Station are given the results of a study of the root system of corn. From this study, it was learned that corn roots do not strike directly downward into the soil early in the season, but they make a rapid growth outward and near the surface. In the sample studied, these latteral roots had attained such a growth in thirty days from the time of planting that the roots from opposite hills three feet apart had met midway between the hills, about four inches below the surface of the ground. At six inches from the hill the roots were only two and one-half inches from the surface. Even at this stage (second cultivation), deep cultivation near the hill (and it is necessary to cultivate corn close early in the season in order to destroy the weeds) would have destroyed some large roots.

Later in the season the roots grew downward more than in the early part of the season, but the plant continued to send out numerous latteral roots also, so that when the corn had reached the stage when cultivation was discontinued, the roots occupied the soil fully between the hills to the depth of two feet. Fig. 4 shows the distribution of the roots at the last cultivation, fifty-five days after planting.

Fig. 5 shows the growth and distribution of the roots which had taken place ninety days after planting. The corn was in the "milk" stage. The hills were three feet and eight inches apart. The great development of large succulent roots, which easily decay and furnish food for the succeeding crop, is perhaps one of the reasons why corn is an excellent rotation for wheat.

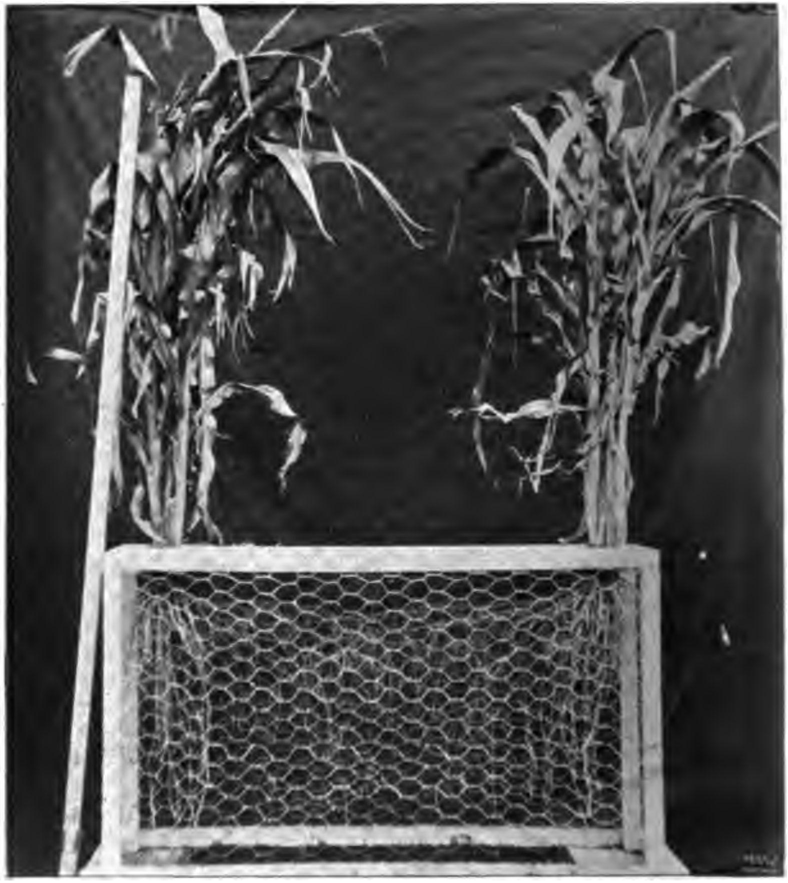
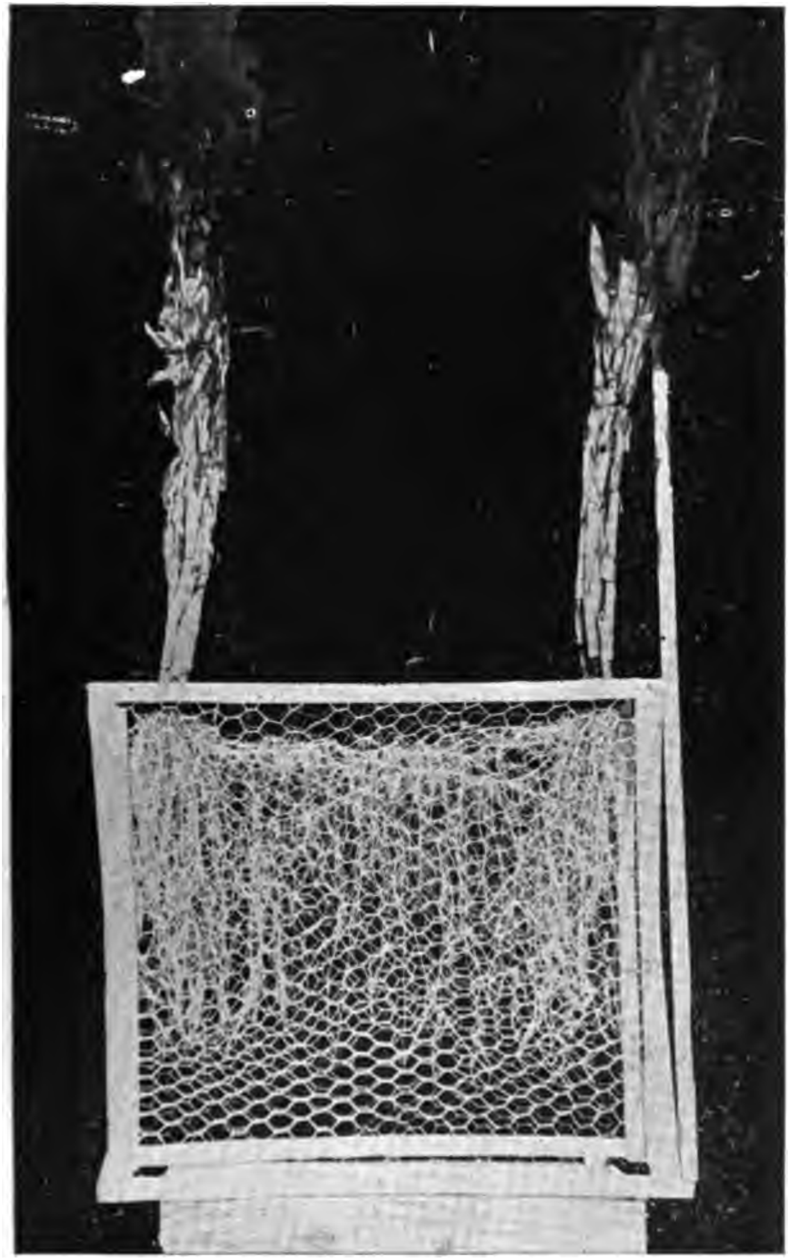


Fig. 4 - Showimg growth and distribution of corn roots between two hills, at the close of cultivation, fifty five days after planting.



[illegible]—Showing root growth of corn when killed by frost ninety days after planting.

HARVESTING AND SAVING THE FODDER.

No comparative experiments have been conducted in this line, but several different methods of harvesting and saving the fodder have been practiced at this Station. The general method of harvesting corn, planted in rows, has been to cut by hand and place in shocks of medium size and allow the fodder to cure in the field until the last of October or the first of November, when the corn was husked and the stalks tied in bundles and hauled in and stacked in small, low ricks, from which the fodder was either fed to the stock whole, in the field or yard, or cut up with a feed cutter and fed in the barn. Often corn is left in the shock in the field and hauled during the winter as it is needed and fed to the stock without husking. The fodder may also be bound into bundles, without husking, at the time of cutting, and left in the shock in the field until late in the fall after cold weather has set in, when it may be stacked without danger of injury by heating.

The Station has a silo which solves the question of taking care of about two hundred tons of green fodder. The fodder is cut from the first to the middle of September and hauled at once to the silo. Without considering the cost of a silo, green fodder is handled at a relatively greater expense than dry fodder, but it is a convenient method of saving the fodder and it offers convenience in feeding in the winter.

For the last two seasons the corn at the Station has been cut with a corn binder. The corn is cut and bound in bundles by the machine, which drops them in bunches of three or four. The only hand labor required is in shocking. This is the most convenient and perhaps the most economical method of harvesting fodder corn when it is grown on a large scale. The use of the sled or wheel cutter is also to be recommended, even in preference to the binder perhaps, when it is the purpose to husk the corn.

When corn is sown or planted in close drills, the grain binder may often be used as a harvester. It is not generally advisable, however, to use the grain binder as a corn binder, except to a limited extent, on account of the strain and wear on the machine, and in the more favorable seasons for growth, the height of the stalks will often be too great to allow the use of the grain binder.

TIME TO HARVEST.

Fodder corn should be cut before frost. The stage of maturity at cutting, provided the corn is not too ripe, is not so important. To make good fodder, corn should be cut before the ears are fully ripe and while the stalks and leaves are still green. The "glazed" stage is considered by many to be the proper time to cut corn, but at any stage in its growth, after tasseling, corn will make excellent fodder if the stalks are well cured and saved. But as stated before the feeding value of the immature fodder is less than that of mature fodder.

It is a difficult problem to get corn fodder dry enough to stack, shred or cut up before winter begins. For this reason huskers, shredders and stalk cutters cannot be used on a large scale successfully in this state. Probably the old system of leaving the stalks in the field and hauling them as they are fed is more practical with us than it is in the corn states. There is little danger, however, in stacking corn fodder after cold weather has begun, nor in cutting up the stalks or shredding them in small quantities to be fed out in a few days, and this is the better and more economical way of preparing and feeding the fodder. When fodder is shredded in the fall, it may be stacked with straw, alternating a layer of straw with a layer of fodder. The dry straw absorbs the excess of moisture from the shredded fodder and heating is avoided.

CORN AS A ROTATION CROP AND SOIL MOISTURE CONSERVER.

In all of the experiments conducted at this Station corn has proved to be an excellent rotation crop for wheat and flax. In the dry season of 1900, the average yield of wheat after wheat on fall plowed land was 5 bushels per acre. The average yield after corn was 24.6 bushels per acre, or nearly twenty bushels greater yield from the land which had grown a crop of corn in 1899. Wheat after corn yielded a trifle better than wheat after potatoes, but a little less than wheat on summer fallow.

In the very wet season of 1901, wheat after wheat yielded 21 bushels, wheat after corn 22 bushels and wheat on summer fallow 18 bushels per acre. Thus the rotation with corn has proven beneficial in two very extreme seasons. The advantage of a previous rotation to corn is most marked in the following wheat crop during a dry season. This seems to be due to the fact that the growing of corn along with the cultivation which the crop receives conserves the moisture in the soil.

CORN CONSERVING SOIL MOISTURE.

In the fall of 1900, determinations of the soil moisture in the several plots which had produced different crops, showed that corn ground contained two inches more water than wheat ground, which was an increase of twenty per cent. in the available water stored in the soil ready for the next year's crop. No other crop had proved to be so great a conserver of the soil moisture. Potatoes and millet ranked next to corn, but the ground of these plots contained one inch less water than the corn ground.

From a study which was made of the moisture content of the soil July 24th, 1900, before the rains came, it was calculated that at that date, ground which was growing corn contained 5.7 inches more water than the ground which was in wheat. (See Bulletin No. 48.)

Professor F. H. King of the Wisconsin Station found that for the production of a twenty-bushel crop of wheat, six acre inches of water was required, or that one inch of water produced three and one-third bushels of wheat. Experiments at this Station indicate that an extra inch of available water in the soil may be equivalent to even more than three and one-third bushels of wheat per acre, during a season in which the crop suffers from drouth. (See Bulletin No. 48.) The conservation of moisture in the soil by the rotation with corn causes a marked increase in the succeeding wheat crop in a dry season.

YIELDS OF WHEAT AFTER CORN.

In Table XVII are given results of an eight year's trial of corn compared with other crops in rotating for wheat.

TABLE XVII.

Corn Compared with Other Crops as a Rotation for Wheat—Results of an Eight Year's Trial, 1892-1899.

METHOD OF ROTATION.	Total yield of wheat in 8 years.	Average yield when wheat was grown.	Presence of weed in 1899.
	bu. per acre	bu. per acre	per cent.
Corn 1 year, wheat 3 years	132.8	22.1	0
Potatoes 1 year, wheat 3 years	139.8	23.3	1
Rape 1 year, wheat 3 years	134.8	22.5	7
Mangels 1 year, wheat 3 years	132.3	22.0	2
Millet 1 year, wheat 3 years	130.8	21.8	½
Summer fallow 1 year, wheat 3 years	130.2	21.7	4
Field peas 1 year, wheat 3 years	126.2	21.0	trace
Wheat continuously	139.2	17.4	25

Corn is superior to summer fallow and stands next to potatoes as a rotation crop for wheat. More wheat was raised in the six crops after two crops of potatoes than in the eight crops when wheat was grown continuously without rotation. As an average for six crops, wheat after corn yielded 4.7 bushels more per acre each year than wheat after wheat. The rotation with corn has thoroughly cleaned the land. Corn is to be preferred to rape as a rotation for wheat, since rape has not proved to be so good a crop to clean the land as corn. In these trials the rape was not pastured but was cut off and hauled away from the plot to be fed.

In another trial in which the land was manured every fourth year, i. e., the fall before the rotation, corn proved superior to millet and summer fallow as a rotation for wheat, as shown in Table XVIII.

TABLE XVIII.

Results of an Eight Year's Trial in Manuring Rotation Crops, 1892-1899.

METHOD OF ROTATION.	Total yield of wheat in 8 years.	Average yield when wheat was grown.	Presence of weeds in 1899.
	bu. per acre	bu. per acre	per cent.
Corn 1 year, wheat 3 years	142.8	23.8	0
Millet 1 year, wheat 3 years	141.3	23.6	0
Summer fallow 1 year, wheat 3 years	134.6	22.4	2
Wheat continuously, not manured	139.2	17.4	25

The manure was applied at the rate of six loads of well rotted manure per acre and plowed under in the fall. The land rotated with corn in this trial has produced 3.6 bushels more wheat in six crops than was produced in eight crops when wheat was grown continuously without rotation or manuring. Comparing the average crops each year, the land which was rotated with corn gave thirty-seven per cent. the larger yield.

FLAX AFTER CORN.

Continuous experiments in growing flax after corn have not been made at this Station. In the dry season of 1900 land which had been previously cropped to corn yielded, by careful estimate, six and one-half bushels (70 per cent.) more flax per acre than land which had been previously cropped to wheat for five years. (The crops were sixteen and nine and one-half bushels per acre respectively.) In 1897 flax on summer fallow yielded six and one-tenth bushels (59 per cent.) more seed per acre than flax after wheat. (The crops were sixteen and four-tenths and ten and three-tenths bushels per acre respectively.) These records and other observations indicate that corn is an excellent rotation for flax as well as for wheat.

PREPARATION OF CORN GROUND FOR SOWING WHEAT OR FLAX.

At this Station corn has always been cut for fodder and removed from the field and the land has generally been fall plowed for wheat. The experience of the last two years, however, seems to prove that it is not necessary and often not desirable to plow corn stubble ground for wheat, provided the corn has been kept clean. No comparative trials have been made at this Station but excellent results have been obtained during the last two seasons from sowing wheat in the corn stubble without plowing.

The land should be pulverized with a disc or acme harrow once or twice before seeding. In using a disc harrow, by lapping one-half, ridging may be avoided and the soil will be put into excellent condition for receiving the seed. There is a certain principle which should be observed in putting seed into the ground. The land ought to be cultivated only as deep as the seed is sown. This allows the best conditions for germination. The firm soil below will supply the seed with moisture and the mellow soil above allows the best conditions for the seed to get air and the full benefit of the warm sunshine. Corn ground unplowed offers a better opportunity to secure these favorable conditions than plowed land.

On corn ground which has been kept clean, a cleaner crop of wheat or flax may be grown without plowing than by plowing, because the plow will turn up a lot of weed seeds which will sprout and grow, but which were buried too deep to grow during the cultivation of the corn. If corn land is sown to flax without plowing, care must be taken to keep the ground cultivated and free from weeds until the flax is sown. The cultivation for flax should be shallower than the cultivation for wheat.

BREEDING AND SELECTING SEED.

For several years the Station has been experimenting with crossing corn and developing new varieties, and improving old varieties by selection. The seed of many of the varieties which had been bred up in this way was lost in the fire which burned the College barn Jan. 4th, 1901. A few kernels of some of the choicer selections were fortunately saved and the work of improving varieties is being continued. Fourteen crosses and selections were planted in the breeding trial last season. It will take several years to develop and fix the type of these new selections, but this is the best and perhaps the only way to get varieties of corn which are adapted to our state. The varieties of corn which can be recommended for general planting in North Dakota at the present time are those sorts which have been grown for several years in the state and in the localitiy to which they have become adapted, by careful selection.

As a rule it is not advisable to send outside of the state for seed corn, unless the purpose is simply to grow fodder. The corn which will ripen and produce the largest crop of ears in a given locality is usually that variety which has grown and ripened seed for the longest period of years in that locality, provided it has been kept pure and true to type and has been bred and selected by the grower with the purpose of adapting it to that particular climate and soil. Attention has been called to several varieties of corn which may be successfully grown and ripened in nearly all parts of the state. Care should be taken, however, to secure North Dakota grown seed of these varieties, and preferably to secure seed which has been grown near the locality in which it is desired to plant the corn. Mercer flint corn, which is a comparatively early variety when propagated from North Dakota grown seed, has failed to ripen at this Station when the seed was secured from South Dakota or southern Minnesota.

SELECTING THE SEED EARS.

Seed corn should be selected in the field early in the fall, before frost, or at least before a hard freeze. It is not necessary and often not desirable to select the seed before the first frost, unless the corn must be cut for fodder, but it is best to select seed before the corn is put into the shock. It is desirable usually to plant a few acres apart for seed, or to leave a few acres of the best corn, when the fodder is harvested, from which seed may be selected. Seed ears should be selected not only for their size and maturity, but for their purity in type and perfect development. The tips and butts should be well filled out. The rows should be regular and not too far apart. The cob should be small in proportion to the size of the ear, and the kernels should be deep set but not too tapering. Only those ears should be chosen which are at a good height on the stalk. The stalk itself should be carefully observed and the seed selected for stalk as well as for ear. The stalk should have good length and size and be well covered with leaves, insuring a good quality and yield of fodder. A good variety of corn may be degenerate when the seed is selected only for earliness with little consideration for other points.

DRYING AND SAVING THE SEED.

When the season is early and the fall is very dry, seed corn may sometimes be successfully dried out of doors under an open shed. It is safer to store the corn in a well ventilated room, which is heated by a stove or otherwise, until the corn is thoroughly dried, before it is exposed to cold weather. If the corn is well cured and kept dry, freezing will not injure the seed. Injury to seed corn is generally due to the fact that the kernels contain too much moisture when hard freezing weather begins and the germ or chit is weakened or destroyed by the freezing. Keeping the corn in a damp cold place, even after it was once well cured, may have the same effect as insufficient drying. It is always safer to test the germination of seed corn before planting it, however well it may have been kept.

Varieties of corn are needed for the different soils of this state which are adapted to our climatic conditions. North Dakota corn growers should study the preparation of soil and general management of crop, such as methods of planting and cultivation, as growing the corn plant is new to most of them.

The season is long enough in North Dakota to mature a crop of corn if the right varieties are planted. Varieties of corn which are said to mature in less than one hundred days in Iowa, Illinois and Nebraska are usually too late in maturing to be practical varieties to plant in this state. Corn does not grow so rapidly nor mature so early in this cooler climate. The average season of growth for corn in North Dakota is about one hundred ten days but corn which will ripen in one hundred days in the corn belt will only reach the soft dough stage here owing to a lack of intensely warm weather. Good drainage and thorough cultivation are important for corn as it enables the plants to make a good growth during the early part of the season by hastening the warming of the soil.

SUMMARY.

1. In 1900 North Dakota planted over 78,000 acres of corn.
2. Only a few types of corn have become adapted to North Dakota conditions. A number of good yielding varieties ripen regularly and produce well.
3. Local corn breeders have bred up a few good strains and the Station is breeding and trying all promising, available sorts, both old and new.
4. The proportion of kernels to cob varies widely with varieties which are considered good.
5. Large growing fodder corn may be used to advantage for thick planting when fodder alone is desired.

6. Corn sowed thick in six inch drills gave the greatest quantity of dry fodder per acre. Corn planted in drills eighteen inches apart and cultivated yielded seven-eighths as much dry matter per acre, of which nearly one-fourth was ears.

7. Corn planted in rows three and one-half feet apart produced the greatest yield of ears, when the stalks grew six inches apart in the row.

8. Land can be kept cleaner by the average corn grower when the crop is planted in check rows and cultivated both ways.

9. Corn planted at the rate of six kernels to the hill gave a heavier yield of grain than thinner planting.

10. Corn planted three inches deep gave a heavier yield of both ears and fodder, as an average for two years, than deeper or shallower planting.

11. The heaviest yield of dry fodder in 1901 was produced when the seed was planted early in June.

12. Corn increases in dry matter per acre rapidly from the time of tasseling until fully ripe.

13. Corn contains more digestible matter per hundred pounds of dry matter after it passes the glazing stage than it does before it reaches it.

14. Shallow cultivation gives better results than deep cultivation as the former disturbs the roots less.

15. Corn may be harrowed to advantage during the early stages of growth if it is planted a little thick and good judgment is used.

16. Corn saved for fodder should be cut before frost.

17. Stack corn in narrow ricks to prevent undue heating.

18. Corn is—next to potatoes—the best preparatory crop for wheat and flax and is superior to a barren summer fallow.

19. Cultivating corn conserves the soil moisture and destroys weeds

20. North Dakota needs seed corn bred especially for local conditions.

21. Select seed corn upon the performance of the entire stalk, giving greatest consideration to the amount of ripe shelled corn which is produced.

22. Have seed corn thoroughly dry when freezing weather comes and store it in a dry place until planting time.

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 52.

THE LENGTH OF THE GROWING SEASON IN NORTH DAKOTA.

By E. F. LADD, J. H. SHEPPERD
and A. M. TEN EYCK.

Any farmer, teacher or student in the state may have this Bulletin mailed to his address, free of charge, upon application.

FARGO, NORTH DAKOTA, U. S. A.,
June 1902.

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THE LENGTH OF THE GROWING SEASON IN NORTH DAKOTA.

TIME REQUIRED TO RIPEN FIELD CROPS AT FARGO.

The urgent demand for information concerning the length of the growing season and the latest date at which it is safe to plant different crops has made the publication of the data contained in Bulletin 52 imperative.

The writers wish to call attention to the fact that the exact degree of cold which will injure wheat depends to some extent upon the stage of growth the plants have reached, and, possibly, upon some other minor points. In the spring season of growth, the order of tenderness seems to be wheat, oats, barley, flax, millet, and corn.

Flax differs from the other plants named, in that if it is cut off by frost at a point below where the first leaves, called seed leaves, come out, it loses its power of growth. It is frequently frosted slightly after it has reached a height of two inches or more without being appreciably injured.

WHEN KILLING FROSTS OCCUR.

The temperature which registers 26° Fahrenheit has been taken as representing what is commonly known as "killing frost." The following table gives the record of killing frosts made upon the Station grounds at Fargo during the past eight years:

TABLE SHOWING DATES OF FIRST KILLING FALL AND LAST KILLING SPRING FROSTS.

SPRING FROSTS			FALL FROSTS		
Year	Date	Temp deg. Fah.	Date	Temp. deg. Fah.	No. days between frosts
1898	May 11	21	Sept. 9	24	121
*1897	June 7	26	Oct. 9	12	124
1900	May 9	25	Sept. 17	26	131
1895	May 21	20	Sept. 30	21	132
1899	May 14	23	Sept. 29	17	138
1901	Apr. 22	25	Sept. 18	23	149
1894	Arp. 15	21½	Sept. 17	20	155
Av. for 7 years	May 10		Sept. 23		136

*Thermometer accidentally broken in the spring of 1896.

From the above table it will be seen that the shortest time which has elapsed between "killing" spring and fall frosts is 121 days; the longest time 155 days; the average length of time 136 days.

The latest spring date was June 9 ; and the earliest fall date was September 9. The earliest spring and latest fall dates were April 15 and October 9.

The average date for the latest "killing" frost is May 10, while the average for killing fall frost is September 23. Upon a percentage basis the above figures indicate that a crop which would be destroyed by a temperature of 26° Fahrenheit would have the following percentage of risks of being injured by frost:

12½ per cent risk of being killed by frost September 9.

50 per cent risk of being killed by frost on or before September 17 to 18.

75 per cent risk of being killed by frost on or before September 22 to 25.

87½ per cent risk of being killed by frost on or before September 30.

100 per cent risk of being killed by frost on or before October 9.

THE LAST SPRING AND FIRST FALL FROSTS.

The following table gives the dates upon which the latest frosts have occurred in the spring, and of the earliest ones in the fall, as recorded upon the Station grounds at Fargo:

TABLE SHOWING DATES OF FIRST FALL AND LAST SPRING FROSTS.

SPRING FROSTS			FALL FROSTS		
Year	Date	Temp. deg. Fah.	Date	Temp. deg. Fah.	No. days between frosts
1895	May 26	29	Aug. 31	30½	97
1897	June 7	26	Sept. 17	29	102
1901	June 7	30	Sept. 18	23	103
1894	May 19	31	Sept. 11	29	115
1898	May 16	30	Sept. 8	27	115
1899	May 18	30	Sept. 18	29	118
1900	May 9	25	Sept. 17	26	131
Av. for 7 years	May 23		Sept. 12		111

From the above table it will be seen that the average time between light frosts is 111 days; while the extreme range is from 97 to 131 days. The average date for the last spring frost for the seven years is May 23; and the average date for the first fall frost is September 12.

LENGTH OF TIME REQUIRED TO MATURE FIELD CROPS.

Following is a tabular statement of the dates of sowing and the number of days required for the earliest and latest ripening grains tried in variety experiments:

TIME REQUIRED FOR FARM CROPS TO MATURE.

Year	Variety of grain	Date seeded	Days maturing
1901	Wheat	Apr. 26 to 27	96 to 99
1900	Wheat	Apr. 14	107
1899	Wheat	May 5 to 8	90 to 99
1898	Wheat	Apr. 28 to 29	92 to 103
*1897	Wheat	May 6	98 to 106
1895	Wheat	Apr. 16	117 to 123
1894	Wheat	May 1	91 to 98
1893	Wheat		83 to 115
	Average number of days maturing		95 to 106
1901	Oats	May 3 to 4	80 to 98
1900	Oats	Apr. 20	99 to 114
1899	Oats	Apr. 8 to 9	85 to 94
1898	Oats	Apr. 29 to 30	91 to 103
*1897	Oats	May 1	101 to 102
1895	Oats	Apr. 18 to 20	86 to 118
1894	Oats	May 18 to 19	80 to 96
1893	Oats		81 to 95
	Average number of days maturing		88 to 102

*The records for 1896 were accidentally lost.

Year	Variety of grain	Date seeded	Days maturing
1901	Barley	May 4	75 to 90
1900	Barley	Apr. 23 to 24	82 to 99
1899	Barley	Apr. 9 to 10	75 to 94
1898	Barley	Apr. 3	80 to 95
1897	Barley	May 1	95 to 97
1895	Barley	Apr. 22 to 24	106 to 111
1894	Barley	May 19 to 21	71 to 87
1893	Barley		71 to 82
	Average number of days maturing		82 to 94
1900	Flax	May 16	77 to 90
1899	Flax	May 15	79 to 88
1898	Flax	May 31 to June 10	77 to 92
1897	Flax	May 3	100 to 109
	Average number of days maturing		83 to 95

Year	Variety of grain	Date seeded	Days maturing
1901	Millet	June 3	90 to 93
1900	Millet	June 5	101
1899	Millet	June 7 to 8	66 to 142
1898	Millet	May 31	86
	Average number of days maturing		81 to 112
1901	Emmer	May 4	90 to 91
1900	Emmer	Apr. 25	95 to 96
1899	Emmer	May 10	86 to 87
1898	Emmer	May 7	88 to 95
1897	Emmer	May 7	95
	Average number of days maturing		91 to 96

Inspection of the above table shows that a range of several days in the time required for grain to ripen is recorded for different years, even when the dates of planting are within a close range. In general, it will be seen that early planted grain requires a longer time to mature than that planted at the usual time. Late seeding has not been studied particularly at this station, but it seems probable that late sown grain would also require extra time to mature. Summarizing the above table gives the following:

Number of Days Required for Different Crops to Mature:
Wheat 95 to 106 days maturing.
Oats 88 to 102 days maturing.
Barley 82 to 94 days maturing.
Flax 83 to 95 days maturing.
Millet 81 to 112 days maturing.
Spelt 91 to 92 days maturing.
Corn about 100 days maturing.

HOW LATE SMALL GRAIN MAY BE SOWN.

The number of days required for ripening the crops listed above is for seasonable planting, and will probably need to be extended for seasons when the final ripening of small grain must take place late in August or early in September and during cool weather.

Late grain will stand for days in cool weather with little change in the degree of ripeness, while grain at a similar stage of maturity during intensely warm summer weather may become ripe and in danger of shelling, in one-half or even one-third the time.

If ten days extra is allowed for grain to ripen, to offset the effect of the cool September weather, May 29th would represent the limiting date for sowing wheat, even when the grower had decided to risk 50 per cent. upon the chance of it being caught by frost in the fall. Oats would stand an equal chance of ripening according to the results of this trial, if sown June 4th. If a risk of 12½ per cent was to be taken, May 27th would represent the latest date for sowing oats, and May 21st the latest time for sowing wheat.

Barley and flax have averaged a week earlier than oats in the trials made at this station. Certain strains of barley—particularly some low-growing hulless ones—are much earlier maturing than the average varieties and hence make less risk in late sowing.

Millet and corn really belong in a class by themselves, owing to the fact that millet is commonly used for hay and hence does not need to mature, while corn ripens its ears or grain considerably after killing frosts occur. Corn is usually grown for both the grain and fodder or stover in this state, and for that reason it is not so serious a matter for it to be immature when frost occurs, as it is in the case of small grain.

The earlier varieties of corn, which have been adapted to North Dakota conditions by several years' selection from home grown seed, are the ones which the authors have in mind in giving the length of time required for corn to mature. Fodder corn may lack a number of days of being ripe and still be a successful crop; but it should be cut before frost kills it. For detailed information relative to varieties, time of harvesting, and other information concerning corn, see Bulletin 51 of this station.

Beans and other tender plants must be referred to the table giving the dates when light frosts have occurred, to determine safe spring and fall dates for them.

The authors desire to call attention to the fact that this bulletin is written upon the data obtained from the limited number of years since the Experiment Station was organized and equipped, and, consequently, has less weight than similar matter will have if published after the Station shall have had twenty-five years to record the facts as they occur.

TIME REQUIRED TO MATURE FIFE AND BLUE STEM WHEAT.

Following is a tabular statement of the time required for strains of fife and blue stem to mature during a series of seven years:

	Exp. Station 66 Fife days	Bolton's Blue Stem days
1894	95	98
1895	119	117
*1897	102	102
1898	102	103
1899	99	98
1900	100	104
1901	98	98
Average for 7 years	102	103

*The record was accidentally destroyed for the year 1896.

The Station records show that different varieties of each of these two common strains of wheat differ in the time required to ripen their grain. Two good and typical varieties were taken for the comparison in order that the variety or breed effect might be the same throughout.

It will be seen that there is a slight range in the time of ripening of the two varieties in particular years; and, also, a range in the time of ripening the same variety in different years. It will be seen, however, that as an average for seven years there is but one day of difference, and that it is in favor of the fife strain.

E. F. Ladd,
J. H. Shepperd,
A. M. Ten Eyck.

NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 53.

FOOD PRODUCTS AND THEIR ADULTERATION.

By E. F. LADD.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
September, 1902.

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FOOD ADULTERATION.

BY E. F. LADD.*

It is now nearly one year since the North Dakota Pure Food Law went into effect and requests are becoming frequent for information regarding the character of the food products sold in the state. We are frequently asked if such and such foods are pure or contain chemical preservatives or coal tar dyes, and whether certain cereal foods are all that is claimed for them. In order that we may answer these questions intelligently we have made an examination of various canned goods, spices, cereal food products, etc., found on the Fargo markets, assuming that these products would be found quite generally over the state.

The last session of the State Legislature enacted a "Pure Food Law," the bill having been introduced by Mr. Thomas of Richland County. We reproduce the text of the law as follows:

ADULTERATION OF FOODS AND BEVERAGES.

(H. B. No. 103—Thomas.)

An Act to prevent the Adulteration, Misbranding and Selling of Adulterated and Unwholesome Foods and Beverages, Prescribing a Penalty for the Violation, and Charging the States' Attorney with the Enforcement Hereof:

Be it enacted, etc.

Section 1. It shall be unlawful for any person, his servant or agent, or while acting as the servant or agent of any other person or corporation, to manufacture for sale or offer for sale any article of food or beverage which is unwholesome or adulterated within the meaning of this act.

Sec. 2. Any article of food or beverage shall be considered as unwholesome or adulterated within the meaning of this act:

First. If it contains any form of aniline dye or other coal tar dye.

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*The analytical data for this bulletin are furnished jointly by the author, Hugh McGuigan, Adele Shepperd, and C. H. Kimberly.

Second. If it contains formaldehyde, benzoic acid, sulphites, sulphurous acid or salicylic acid.

Third. If any substance or substances have been mixed with it so as to reduce or lower or injuriously effect its quality or strength, so that such article of food or beverage when offered for sale, shall deceive or tend to deceive the purchaser.

Fourth. If any inferior or cheaper substance or substances have been substituted wholly or in part for the article, so that the product, when sold, shall deceive or tend to deceive the purchaser.

Fifth. If any necessary valuable constituent of the article has been in whole or in part abstracted.

Sixth. If it be an imitation of or offered for sale under the specific name of another article.

Seventh. If it is labeled or branded so as to deceive or mislead the purchaser.

Eighth. If it consists wholly or in part of a diseased, decomposed, filthy or putrid animal or vegetable substance.

Provided, that an article of food or beverage shall not be deemed adulterated in the following cases:

First. If it be a compound or mixture of recognized food products and not included in definition sixth of this section.

Second. In the case of candies and chocolates if they contain no terra alba, barytes, talc, chrome yellow or other mineral substances, or aniline dyes or other poisonous colors or flavors detrimental to health.

Third. If in the case of baking powders or any mixture or compound intended for use as a baking powder they have affixed to each and every box, can or package containing such powder or like mixture or compound, a light colored label upon the outside and on the face of which there is distinctly printed with black ink and in clear, legible type the name and address of the manufacturers, the true and correct analysis of each and all the constituents or ingredients contained in or contributing a part of such baking powders, or mixture or compound intended for use as a baking powder.

Sec. 3. Any person violating any of the provisions of this act shall be deemed guilty of a misdemeanor and shall for each offense be punished by a fine of not less than twenty-five ($25) dollars or more than one hundred ($100) dollars, and all necessary costs, including the expense of analyzing such adulterated articles when said person has been found guilty under this act.

Sec. 4. It shall be the duty of the States Attorney to prosecute all persons violating any of the provisions of this act.

Sec. 5. All acts and parts of acts in conflict with the provisions of this act are hereby repealed.

In the examinations undertaken no attempt has been made to determine all adulterants present. For example, many jellies, jams, etc., claiming to be certain fruit, were found to have as a basis generally apple jelly, flavored, sweetened and colored to represent the genuine article. In some cases the only nutritive product was starch paste, an example of which is mentioned in the case of a certain pail jelly, a cheap product largely sold in the country districts.

Our aim has been more to determine whether chemical preservatives known to be harmful were present or whether the foods contained coal tar dyes prohibited under the law.

We may first consider the question of chemical preservatives and what trustworthy authorities say regarding their use in food products.

CHEMICAL PRESERVATIVES.

The use of certain preservatives in food products is prohibited under the state law.

Sec. 2. "Any article of food or beverage shall be considered as unwholesome or adulterated within the meaning of this act."

Second. "If it contains formaldehyde, benzoic acid, sulphites, sulphurous acid, or salicylic acid."

It has been most conclusively shown that the use of the above mentioned preservatives are injurious to health, that they retard digestion, and are not to be used except as medicine under the direction of a physician.

I quote from the statement of a few competent authorities regarding the use of chemical preservatives in foods. Says Dr. S. W. Johnson of Yale University in the report of the Connecticut Experiment Station for 1897, page 3:

"The already extensive and rapidly increasing use of antiseptics or preservatives, not evident and not known to the purchaser or consumer of foods and drinks, has become a serious evil that demands notice here.

"Antiseptics are preventives of the decay, fermentation and putrefaction of animal and vegetable substances. These processes and many other similar ones that are associated with disease in animals and plants, are due to the vegetative activity of a variety of fungi and bacteria. Antiseptics operate by suspending or destroying the life of these organisms or that of the germs out of which they develop.

"Antiseptics are, accordingly, for the most part, decided poisons. In a certain dilution, with water for example, they may counteract or kill the lower, weaker organisms of fermentation, etc., without apparent injury to the higher and stronger plants and animals. Whether any one antiseptic shall operate as a harmless preservative, preventive or remedy, or as an unhealthful or even fatal poison to the consumer of food and drink containing it, depends upon the quantity and frequency of the dose.

"The power of different living things, small or large, to withstand the action of antiseptics and of poisons generally, is very various, and doubtless, plants as well as animals, may gradually so adapt themselves to the attacks of poisonous substances as to acquire a considerable degree of tolerance or even of immunity."

Says Dr. Albert B. Prescott of Michigan University.*

"* * * The value of food is dependent upon digestion. The digestive apparatus, exceedingly complex as it is, varies widely with different individuals. An article of food nutritious to one person is injurious to another person. For these reasons it is of great importance to the vigor and development of mankind that individuals should be protected against the concealment of constituents of food offered upon the market. Individual discretion and responsibility become impossible when preservatives and antiseptics, those incapable of detection by taste and appearance, are secretly introduced into food. An article of food charged with a preservative not only contains a small quantity of the preservative article, liable in itself to effect the body after habitual use, but the entire food material is to some extent modified and altered by the action of a preservative. The very fact that the food is prevented from decomposition, or from certain kinds of decomposition, is evidence that the food has suffered an alteration. A food that is braced against decomposition may be found to be braced against digestion. At any rate, it will be distinctly different from food not so treated, as for instance, salted meat is different from fresh meat. Unlike that of this instance, however, the difference may not be observable by taste and appearance. The purchaser is helpless to distinguish the fresh article from the stale article. The full opportunity of the purchaser and consumer of food to exercise his own personal choice in the selection of foods is of great importance to public health at large, and to the vigor and vitality of sucessive generations of men and women.

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*See report of Dairy and Food Commissioner of Michigan for 1901, page 11.

For these among other reasons it is the duty of the state to make the concealment of preservatives in foods a legal offense."

Halliburton finds that the use of formalin prevents or retards both gastric and pancreatic digestion and retards the curdling of milk by rennet. He further states that its use disintegrates blood, and irritates the skin, hence it must be much more harmful to the delicate membrane of the alimentary canal.

Dr. Henry Leffmann of Philadelphia says: "Formaldehyde possesses the power of rendering nitrogenous matters insoluble and more or less indigestible."

Says Dr. Morrison of Indianapolis regarding the use of formaldehyde in milk: "My animal experiments not yet concluded, show that young animals fed upon this milk will not thrive and are subject to intestinal troubles. No longer ago than yesterday the 'laboratory cat' was made quite sick by being fed upon milk which had been collected by our inspectors and on sale in the city. Formalin was present."

I have noticed that when formaldehyde is used in milk that in nitrogen determinations where concentrated sulfuric acid is used in the disintergration a half longer is required than where the milk is free from formaldehyde.

Salicylic acid is frequently employed as a food preservative, but it is a dangerous product and that most conservative body of men constituting the Paris Academy of Science have forbidden even the smallest addition of salicylic acid or salicylates to food as liable to cause injury where weakness of the kidneys or digestive organs exist.

Palpitation of the heart, sleeplessness, and headache are some of the prevalent but minor symptoms, noticable when salicylic acid is administered even in as small doses as at times found in food.

Professor Hummel says: "The various forms of chemical preservatives and the coal tar minerals colors are the most important in the first class. There is no doubt but that the chemical preservatives when used in human foods are generally injurious. They are used solely to prevent fermentation, and since the processes of digestion are fermentation processes, the chemical preservatives must work an injury. Their use in milk ought especially to be condemned in the severest terms, for milk is such a universal food, and is used to so large an extent by children and invalids, that in such cases they must prove particularly injurious.

The more common forms of chemical preservatives now used are borax, boric acid, salicylic acid, salts of benzoic and formalin. They are used in a great variety of foods, such as butter, milk and cream, jellies, preserves, meats, oysters, fish, canned vegetables, catsups, pickles, etc."*

Much more evidence could be presented to show the harmfulness of chemical antiseptics when employed as food preservatives. The results which are presented in the following pages show conclusively that these preservatives are present in many food products now offered for sale in this state. Notwithstanding the law makes it a misdemeanor to offer the same for sale, it seems that many of the producers are making no attempt to comply with the law. The merchant may be honest in his intentions, for he has no means of knowing that the goods contain products detrimental to health, unless so informed by the manufacture.

COAL TAR DYES.

Coal tar dyes are extensively employed in coloring canned and preserved goods, candies, sausages, catsups, most of the preserves and jellies, carbonated beverages, etc. Many of these coal tar dyes are known to be poisonous and they are only employed to improve the appearance of inferior, damaged or adulterated food products.

The law is explicit regarding the use of these dyes in the following clause:

It shall be deemed adulterated. "If it contains any form of aniline dye or other coal tar dyes."

The data presented in these pages shows the use of coal tar dyes to be quite general in some of our common food products like catsups, jellies, and canned goods.

Says Prof. Winton* regarding coal tar dyes:

"The relation of coal tar colors to public health first deserves attention. The experiments made with dogs and other animals by Cazeneuve and Lepine, Weyl, and others have proved beyond doubt the poisonous nature of picric acid, dinintrocresol, and Martius yellow, among nitro-colors, and of orange 11 and metanil yellow

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*See Minnesota Dairy aud Food Commissioner's Report for 1901, page 1063.

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*Report of Connecticut Experiment Station for 1901, page 180.

among the azo-colors. Fuchsine, sulphonated nitro-colors, and most of the azo-colors tested did not act as poisons, although some of them produced vomiting, others diarrhœa, and others still developed slight albuminuria.

"Although there is evidence that most of the coal tar dyes are not injurious to some of the lower animals, it is not safe to assume that they are entirely harmless to human beings. The dog, the animal used in most of Weyl's experiments, has a proverbially strong stomach and eats, with no apparent discomfort, many things which would disturb the digestion of a man.

"The unwholesomeness of certain coal tar dyes not classed as poisons is indicated by the experience of Weber, who tested their effect on the artificial digestion of fibrin with pepsin and with pancreatin. He found that the oroline yellow (acid yellow) retarded the action of pepsin and that of methyl orange, saffoline, (acridine red) and magenta (fuchsine) seriously interfered with the pancreatic digestion, where the quantity of dye made one part in 1600 of the solution. Of these, fuchsine, at least when pure, had been pronounced entirely harmless by earlier investigators, who based their conclusions on experiments with lower animals and some few with man."

These dyes are used to improve the appearance of inferior or adulterated goods and for the purpose of deceiving the purchaser who often assumes he is buying an excellent article.

The use of both coal tar dyes and preservatives in food products, especially for young children, is to be strongly condemned and especially is this true of milk where preservatives are not infrequently employed. On this point we quote from the Eighth Biennial Report of the Minnesota Dairy and Food Commissioner. Page 1063:

"Of the coal tar dyes some are now known that are not injurious, but since some are virulent poisons the use of all ought to be prohibited. They are used in all the cheap and highly colored candies, and, of course, here are eaten principally by children. They are also used in sausages, in all catsups, in most preserves and jellies, and in butter and cheese. Most of the highly colored fruit syrups and crushed fruits of our soda fountains contain these dangerous colors, as do also many of the bottled carbonated beverages. In this case come also the poisonous salts of zinc and copper which are used in canned vegetables, not so much to impart a color, as to preserve the original green color of the vegetable."

JELLIES, JAMS, MARMALADES, AND PRESERVES.

It has been found that nearly all the jellies, jams and preserves examined, such as strawberry, current, raspberry, orange, pear, etc., consist largely of other fruit jelly, mainly apple, artificially flavored, containing preservatives and often colored in imitation of the real product. Some of the jellies, etc., examined we are confident do not contain a trace of the fruit they claim to be and as given on the label. No. 142, a blackberry jelly, was found to be starch paste, sweetened, colored with coal tar dyes to imitate blackberry, preserved with formalin and sulphurous acid and artifically flavored.

Campbell's strawberry jam No. 130 was probably wholly artificial, containing formalin, benzoic acid and coal tar dye.

Raspberry preserves No. 138 put up by the Towle Preserving Co., St. Paul., was also artificial, containing coal tar dye to give color and formalin and salicylic acid to prevent fermentation.

Of the 33 samples of jams, jellies and preserves, not one was free from chemical preservatives and in some instances at least three distinct classes of preservatives were present in the same sample. It will be noticed also that the adulterations are not confined to the cheap grade of goods, but are to be found in the best and highest grade products on the markets, in the products of firms of the highest standing in the commercial world and who claim absolute purity for their goods. The question then may be fairly asked whether they are sending to this state their better grade of goods or whether inferior products are being used for North Dakota trade?

JAMS, JELLIES, ETC.

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost	Preservatives	Remarks	Color
43	The Best Ever	Fargo Preserving Co.	T. E. Yerxa	420	25	Formalin		
49	Batavia Green Gage Plum	Batavia Pres. Co	T. E. Yerxa	416	25	Formalin and Benzoic acid		
49a	Home Pure Fresh Fruit Strawberry	Jersey Pack. Co., San Jose, Cal. Hamilton, O.	T. E. Yerxa	439	25	Formalin		Coal tar
51	Heinz Currant Jelly	H J. Heinz & Co., Pittsburg	T E. Yerxa	291	25	Formalin		
52	Medallion Peach with Apple Jelly	Bishop & Co., Los Angeles	T. E Yerxa	283	....	Formalin		
54	Pear (Fresh)	Batavia Preserving Co.	T. E. Yerxa	515	35	Formalin and Benzoic acid		
55	Duncans Extra Standard Apple Jelly	Fargo Preserving Co.	T. E. Yerxa	259	20	Formalin		
71	Monarch Brand Concord Grapes	Reid, Murdoch & Co.	C J. Calmer	276	30	Formalin and Salicylic acid		
72	Dunkley's Red Raspberries	Dunkley's Pres. Co., Kalamazoo, Mich.	C. J Calmer	617	30	Formalin		
94	Red Raspberries Pure Fruit	Reid, Murdoch & Co.	C. J. Calmer	426	25	Formalin		Coal tar
98	Reindeer Yellow Peaches	Reid, Murdoch & Co.	C. J. Calmer	919	25	Formalin	Large amount	
100	Honey Dew Red Raspberries	Erie Pres. Co., Buffalo, N. Y.	C J Calmer	745	25	Formalin and Benzoic acid		
106	Monarch Extra Strawberries	Reid, Murdoch & Co.	C. J. Calmer	657	30	Formalin	Large amount	
109	Golden Niagara Extra Red Raspberries	Niagara Pres Co., Lockport Co., N. Y	C. J. Calmer	627	30	Formalin	Large amount	
116	Tremaines Peeled Apricots, Extra Stand'd Cal. Fruits	Reid, Murdoch & Co.	Fargo Grocery Co.	932	30	Formalin		
121	Our Favorite Plum Butter	Farnham Canning Co. Farnham, N. Y.	Fargo Grocery Co.	1013	18	Formalin and Borax		
123	El Campo White Cherries	Hunt Bros. Fruit Pres. Co., Santa Rosa, Cal.	Fargo Grocery Co.	892	25	Formalin		
124	Mound City Peaches	E. O. Hudson & Co., Baltimore	Fargo Grocery Co.	905	15	Formalin		
125	Banquet Bartlett Pears	Southern Cal Packing Co., Los Angeles	Fargo Grocery Co.	848	25	Formalin	Large amount	

JAMS, JELLIES, ETC. (Continued.)

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost	Preservatives	Remarks	Color
127	Anderson's Cranberry Sauce	Anderson Pres Co., Camden, N. Y	Fargo Grocery Co	808	20	Formalin	Large amount	Coal tar
130	Campbell's Strawberry Jam	Joseph Campbell Pres. Co, Camden. N Y.	Fargo Grocery Co.	436	25	Formalin and Benzoic acid		Coal tar
132	Old Virginia Marmelade	Geo K McMechen, Wheeling. W Va	Fargo Grocery Co.	429	25	Formalin. Sulphurous acid and Benzoic acid		
133	Raspberry Preserves	Towle Pres Co., St Paul	Fargo Grocery Co.	945	25	Formalin and Salicylic acid		Coal tar
136	Pure Unfermented Grape Juic	Reid, Murdoch & Co	Fargo Grocery Co		35	Benzoic and Salicylic acid	Small amount	
137	Quaker Brand Pear	Wm R Manierre, Chicago	Fargo Grocery Co.	462	25	Formalin		?
138	XX Brand Strawberries	P. J Ritter, Philadelphia	Fargo Grocery Co.	370	25	Formalin		Coal tar
141	Home Brand Apricots	Grigg. Cooper & Co, St Paul	Fargo Grocery Go.	297	15	Formalin		
142	Blackberry Jelly	Davenport Refining Co., Davenporr, Iowa	Fargo Grocery Co.	13 lbs	50	Formalin and Sulphurous acid		Coal tar
148	Currant Jelly	Manierre-Yoe Syrup Co., Chicago	Fargo Grocery Co	542	25	Formalin and Sulphurous acid	Most probably artificial	A red dye
149	Felmo Brand Blackberry	Franklin McVeagh & Co, Chicago	Fargo Grocery Co	365	25	Formalin, Benzoic acid and Sulphurous acid		Bright Crimson much
150	Heinz Preserved Raspberries	H J. Heinz & Co, Pittsburg	Fargo Grocery Co.	615	50	Formalin	Small amount	
152	Peerless Brand Red Raspberries	C H. Pearson Packing Co, Baltimore	Fargo Grocery Co	576	15	Formalin	Contents spoiled and uneatable	
172	Cupid Brand Crawford Peaches	Dunkley Pres Co., Kalamazoo, Mich	E. A. Perry	977	30	Formalin	moderate amount	

CATSUPS.

Of the eight samples of catsups examined all contained coal tar dyes to give color, and seven of the eight contained chemical preservatives, and Nos. 23 and 99 contained unnecessarily excessive amounts to act as preservatives and could not but prove harmful to those consuming the products. While it is difficult to distinguish between tomato and certain other vegetable products in some samples, I am confident other products were used, as for example pumpkin pulp to help give consistency to the mass. The full results are presented in the following table, and it will be observed that No. 171 contains three well known chemical preservatives, and in the case of No. 99 a brand labeled "Superior Tomato," a very inferior compound product, the name of the producer is not given. In this there was present a large amount of coal tar color, a small amount of formalin and an excessive amount of salicylic acid, but in spite of the preservatives and coloring matter the contents of the bottle were very dark and in bad condition.

CATSUPS.

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost Cents	Preservatives	Remark	Color
22	Nail City	W. Va. Preserving Co., Wheeling, W. Va.	T. E. Yerxa	......	15	....		Coal tar
23	Home Made Tomato	Fargo Preserving Co.	T. E. Yerxa	......	20	Benzoic acid	Large amount	Coal tar
24	Monarch Tomato	Reid, Murdock & Co. Chicago.	T. E. Yerxa	......	25	Benzoic acid		Coal tar
25	Snyder's Home Made	T. A. Snyder Preserving Co.	T. E. Yerxa	......	25	Benzoic acid		Coal tar
26	Batavia	Batavia Preserving Co.	T. E. Yerxa	......	17½	Benzoic acid		Coal tar
96	Priscilla Tomato	Franklin McVeagh & Co.	C. J. Calmer	......	15	Formalin, Salicylic acid	Small amount	Coal tar
171	Superior Tomato	Eagle Vinegar & Pickle Works, St. Louis, Mo.	E. A Perry	......	25	Formalin, Sulphurous acid Benzoic acid Formalin	Small amount Small amount	Analin Orange red
9	Superior Tomato	Not given	C. J Calmer	......	10	Salicylic acid	Large amount	Coal tar

SOUPS.

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost Cents	Preservatives	Remarks	Color
110	Mock Turtle	Franco American Food Co.	Fargo Grocery Co.	499	22	Formalin	Very small amount	
122	Heinz Tomato	H. J. Heinz & Co. Pittsburg	Fargo Grocery Co.	950	30	Formalin		
27	Van Camp's Tomato	Van Camp Preserving Co.	T. E. Yerxa	350	10	....		Coal tar
151	Premier Concentrated Chicken	Libby & McNeill, Chicago	O. S. Hadeland	345	10	Formalin	Very small amount	
178	Yacht Club Tomato	Reid, Murdoch & Co.	E. A. Perry	290	15	Formalin		Strong orange yellow dye

Of the five samples of soup examined four contained preservatives and the one free from preservatives contained coal tar dye, so that all were found adulterated. No. 178 contained an excessive amount of orange yellow coal tar dye.

CATSUPS.

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost Cents	Preservatives	Remark	Color
22	Nail City	W. Va. Preserving Co., Wheeling, W. Va.	T. E. Yerxa	......	15	....		Coal tar
23	Home Made Tomato	Fargo Preserving Co.	T. E. Yerxa	......	20	Benzoic acid	Large amount	Coal tar
24	Monarch Tomato	Reid, Murdock & Co. Chicago.	T. E. Yerxa	......	25	Benzoic acid		Coal tar
25	Snyder's Home Made	T. A. Snyder Preserving Co.	T. E. Yerxa	......	25	Benzoic acid		Coal tar
26	Batavia	Batavia Preserving Co.	T. E. Yerxa	......	17½	Benzoic acid		Coal tar
96	Priscilla Tomato	Franklin McVeagh & Co.	C. J. Calmer	......	15	Formalin, Salicylic acid	Small amount	Coal tar
171	Superior Tomato	Eagle Vinegar & Pickle Works, St. Louis, Mo.	E. A Perry	......	25	Formalin, Sulphurous acid Benzoic acid Formalin	Small amount Small amount	Analin Orange red
9	Superior Tomato	Not given	C. J Calmer	......	10	Salicylic acid	Large amount	Coal tar

SOUPS.

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost Cents	Preservatives	Remarks	Color
110	Mock Turtle	Franco American Food Co.	Fargo Grocery Co.	499	22	Formalin	Very small amount	
122	Heinz Tomato	H. J. Heinz & Co. Pittsburg	Fargo Grocery Co.	950	30	Formalin		
27	Van Camp's Tomato	Van Camp Preserving Co.	T. E. Yerxa	350	10			Coal tar
151	Premier Concentrated Chicken	Libby & McNeill, Chicago	O. S. Hadeland	345	10	Formalin	Very small amount	
178	Yacht Club Tomato	Reid, Murdoch & Co.	E. A. Perry	290	15	Formalin		Strong orange yellow dye

Of the five samples of soup examined fonr contained preservatives and the one free from preservatives contained coal tar dye, so that all were found adulterated. No. 178 contained an excessive amount of orange yellow coal tar dye.

CORN AND SUCCOTASH.

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost Cents	Preservatives	Remarks
44	Minnesota Sugar Corn	Fairbault Canning Co.	T E. Yerxa	584	8	Sulphurous acid	
45	Batavia Brand	Batavia Pres. Co, Batavia, N. Y.	"	608	15	Saccharin	
46	Mondamin Brand Sweet Corn		"	568	7	Saccharin	
47	U. S. Cream Corn	U. S Canning Co., Fredonia, N. Y.	"	592	12½		
48	Monarch Extra Sweet Corn	Reid, Murdoch & Co., Chicago	"	614	15	Saccharin	Large amount
90	White Horse Corn	Reid, Murdoch & Co., Chicago	C. J. Calmer	588	15	Saccharin	
109	Extra Succotash Monarch Corn	Reid, Murdoch & Co, Chicago	"	595	15	Saccharin, borax or boraric acid	Small amount
173	Golden Harvest	Portland Packing Co., Maine	E. A. Perry	629	15	Formalin	Very small amount
176	Golden Harvest Sugar Corn	Portland Packing Co., Maine	"	529	15	Formalin	Small amount

Of the nine samples of corn and succotash examined five were sweetened with saccharin, the coal tar sugar. In some instances where the sweetening was employed the corn was an inferior product, and this was true particularly of No. 48. Field corn was substituted for sugar corn.

PORK AND BEANS.

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost Cents	Preservatives	Remarks
82	Star Brand Pork & Tomato Sauce	Armour Canning Co., Omaha, Neb.	C. J. Calmer Fargo Grocery Co.	595	15		
128	Pork and Beans with Chili Tomato Sauce	Armour Packing Co., Kansas City.		669	15	Salicylic acid	Small amount
126	Heinz Baked Beans	H. J. Heinz & Co , Pittsburg	"	609	18	Formalin	
104	Honey Dew Wax Beans, extra small	Erie Pres. Co., Buffalo, N. Y.	C. J. Calmer Fargo Grocery Co.	596	15	Formalin	
120	Shield Refuge Beans	J S. Farren & Co., Baltimore		....	15	Formalin Sulphurous acid	Very small amount
153	Heinz Baked Beans with Tomato Sauce	H J. Heinz & Co., Pittsburg	O. S. Hadeland	639	15	Formalin	Very small amount

Of the six samples of pork and beans examined five contained chemical preservatives.

Because preservatives or coloring matter is not mentioned as being present is not to be taken as conclusive evidence that none were used, but rather that there was no indication of the kinds for which we were testing.

TOMATOES.

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost Cents	Preservatives	Remarks	Color
29	U. S. Solid Packed Tomatoes	U. S Canning Co., Fredonia, N. Y.	T. E. Yerxa	664	15			
30	Eden Brand	Alfred Eden & Co., Baltimore, Md.	"	938	12½	Formaldehyde	Very small amount	Anilin small amount
31	Monarch Extra	Reid, Murdoch & Co	"	1071	17			
32	Huntley Haynes & Co's First Quality	Wm Tait for H. H & Co.	"	992	12½			
33	Golden Brand	Wm. McKinley Canning Co., Lennox, Madison Co., N, Y.	"	961	15	Formaldehyde	Small amount	Anilin small amount
34a	Batavia Brand	Batavia Preserving Co	"	1032	17			
34b	Belmont Brand	W. N. Greenland, Cooptown, Md.	"	960	13½			
91	Ora Brand	Foutana & Co, San Francisco.	C J. Calmer Fargo Grocery Co.	841	16	Borax or boric acid	Small amount	
131	Rocky Ford Brand	Edw L. Phillips, Armiger, Md.		980	15	Formalin		
21	Oakdale	W. W. Bradford, Emmorton, Md	T. H. Yerxa	....	15			

PORK AND BEANS.

No.	BRAND	PRODUCER	Sold by	Weight Grains	Cost Cents	Preservatives	Remarks
82	Star Brand Pork & Tomato Sauce	Armour Canning Co., Omaha, Neb.	C. J. Calmer	595	15		
128	Pork and Beans with Chili Tomato Sauce	Armour Packing Co., Kansas City.	Fargo Grocery Co.	669	15	Salicylic acid	Small amount
126	Heinz Baked Beans	H. J. Heinz & Co , Pittsburg	"	609	18	Formalin	
104	Honey Dew Wax Beans, extra small	Erie Pres. Co., Buffalo, N. Y.	C. J. Calmer	596	15	Formalin	
120	Shield Refuge Beans	J S. Farren & Co., Baltimore	Fargo Grocery Co.	....	15	Formalin Sulphurous acid	Very small amount
153	Heinz Baked Beans with Tomato Sauce	H J. Heinz & Co., Pittsburg	O. S. Hadeland	639	15	Formalin	Very small amount

Of the six samples of pork and beans examined five contained chemical preservatives.

Because preservatives or coloring matter is not mentioned as being present is not to be taken as conclusive evidence that none were used, but rather that there was no indication of the kinds for which we were testing.

LEMON EXTRACT.

A standard lemon extract or essence is made in accordance with the requirements of the United States Pharmacopœia and should contain 5 per cent of lemon oil.

An extract so made gave by polariscope reading and using the factor 62.5, as the per cent of oil 4.81, therefore, an extract weaker than this could not be considered as standard. In judging of extracts we shall use this as the standard of comparison.

LEMON EXTRACTS EXAMINED TOGETHER, WITH RESULTS.

57 Double Strength Extract Lemon.
Produced by Wm. McMurray & Co., St. Paul, Minn.
Sold by T. E. Yerxa, Fargo, N. D.
Alcohol .... Some methyl
Oil of Lemon .... None
Color .... Coal tar dyes

An artificial product, containing no oil of lemon, but an imitation colored with coal tar dye.

115 Lemon Extract Triple Strength.
Producer, Bastine & Co., New York.
Sold by Fargo Grocery Co.
Alcohol ....
Oil of Lemon .... 3.50 per cent.
Color .... Natural

Not of standard strength.

93 Double Extract of Lemon.
Produced by Emil Aubrecht, Minneapolis, Minn.
Sold by C. J. Calmer, Fargo, N. D.
Alcohol .... Methyl present
Oil of Lemon .... None
Color .... Coal tar dyes

An artificial product, colored with coal tar dye and containing no true oil of lemon.

113 Concentrated Extract of Lemon.
Produced by Standard Chemical Co., St. Louis, Mo.
Sold by Fargo Grocery Co.
Alcohol .... Methyl present
Oil of Lemon .... None
Color .... Artificial

An artificial product, containing no oil of lemon.

147 Standard Extract of Lemon.
Produced by—Name not given.
Sold by O. S. Hadeland, Fargo, N. D.
Alcohol .... Very low
Oil of Lemon .... None
Color .... Vegetable color

An artificial product, highly colored and containing no oil of lemon.

160 Eddy's Double Strength Extract of Lemon.
Produced by Eddy & Eddy, St. Louis, Mo.
Alcohol .... Considerable methyl
Oil of Lemon .... 0.37 per cent. (?)
Color .... None

Artificial product, containing very little, if any, true oil of lemon.

145 Pure Concentrated Extract of Lemon.
Produced by J. H. Bell & Co., Chicago, Ill.
Sold by O. S. Hadeland, Fargo, N. D.
Alcohol .... Methyl present
Oil of Lemon .... 6.12 per cent.
Coloring Matter .... Natural

This product is of good strength, but not wholly free from wood spirits.

116 Gillett's Double Extract of Lemon.
Produced by E. W. Gillett, Chicago, Ill.
Sold by Fargo Grocery Co.
Alcohol .... Pure
Oil of Lemon .... 5.31 per cent.
Color .... Natural

This is a pure product of good strength.

61 Yerxas Triple Strength Extract of Lemon.
Produced by Yerxa Bros. & Co., Minneapolis, Minn.
Sold by T. E. Yerxa, Fargo, N. D.
Alcohol .... Pure
Oil of Lemon .... 3.05 per cent.
Color .... Natural

Pure, but considerably below strength.

60 Burnett's Standard Flavoring Extract of Lemon.
Produced by Joseph Burnett & Co., Boston, Mass.
Sold by T. E. Yerxa, Fargo, N. D.

Alcohol	**Pure**
Oil of Lemon	**8.81 per cent.**
Color	**Natural**

A pure product, containing a high per cent of lemon oil.

Of the ten samples examined five, or 50 per cent., were purely artificial, and with one exception contained no trace of lemon oil; two were below standard strength, and three were above standard strength.

VANILLA EXTRACT.

Vanilla extract is obtained from the vanilla bean by macerating with alcohol. The alcohol extracts vanillin, vanilla resin, coloring matters, etc. The extract of Tonka beans, coumarin is largely used as an artificial vanillin. The following shows the results for the samples of vanilla extracts examined:

EXTRACTS EXAMINED.

58 Columbia Concentrated Extract Vanilla.
Producer—No name given.
Sold by T. E. Yerxa, Fargo, N. D.

Vanillin	**Present**
Coumarin	**None**
Resin	**Present**
Alcohol	**Low**
Color	**Caramel**

A product of low strength, and colored with caramel.

59 Yerxa's Triple Strength Extract of Vanilla.
Produced by Yerxa Bros. & Co., Minneapolis, Minn.
Sold by T. E. Yerxa, Fargo, N. D.

Vanillin	**Present**
Coumarin	**None**
Resin	**Present**
Alcohol	**Medium**
Color	**Caramel**

An extract of medium strength, colored with caramel.

62 Burnett's Pure Extract Vanilla.
Producer, Joseph Burnett Co., Boston, Mass.
Sold by T. E. Yerxa, Fargo, N. D.

Vanillin	**Present**
Coumarin	**None**
Resin	**Present**

Alcohol	Good strength
Color	None

Pure and of high strength.

95 Double Extract of Vanilla.
Producer, Crown Chemical Co., Minneapolis, Minn.
Sold by C. J. Calmer, Fargo, N. D.

Vanillin	Present
Coumarin	Very large
Resin	Present
Alcohol	Fair amount
Color	Caramel

An extract of Tonka beans containing a small amount of vanillin. Not properly labeled.

101 Priscilla Extract of Vanilla.
Producer, Franklin, MacVeagh & Co., Chicago, Ill.
Sold by C. J. Calmer, Fargo, N. D.

Vanillin	Present
Coumarin	Present
Resin	None
Alcohol	Medium strength
Color	Coal tar dyes

An artificial vanillin and extract of Tonka beans, colored with coal tar dyes.

114 Gillett's Double Extract Vanilla.
Producer, E. W. Gillett, Chicago. Ill.
Sold by Fargo Grocery Co., Fargo, N. D.

Vanillin	Present
Coumarin	None
Resin	Present
Alcohol	Good strength
Color	None

A pure product of good strength.

117 Bastine's Pure Extract Vanilla.
Producer, Bastine & Co., New York.
Sold by Fargo Grocery Co., Fargo, N. D.

Vanillin	Present
Coumarin	Present
Resin	Present
Alcohol	Good strength
Color	None

A mixed extract of vanilla and Tonka beans. Therefore, not correctly labeled.

143 Concentrated Extract Vanilla.
Producer, J. H. Bell & Co., Chicago, Ill.
Sold by O. S. Hadeland, Fargo, N. D.

Vanillin	Present
Coumarin	None
Resin	Present
Alcohol	Fair strength
Color	Caramel

A pure product of fair strength, colored with caramel or heated to high in process of manufacture.

144 Monogram Extract Vanilla.
Producer, Grant & Morris, Fargo, N. D.
Sold by O. S. Hadeland, Fargo, N. D.

Vanillin	Present
Coumarin	Present
Resin	Present
Alcohol	Low strength
Color	Caramel

A mixed extract of vanilla and Tonka beans, colored, of medium strength, and not properly leabeled.

158 Tillmann's Vanilla.
Producer, Tillman & Bendel, San Francisco, Cal.
Sold by E. A. Perry, Fargo, N. D.

Vanillin	Present
Coumarin	None
Resin	Present
Alcohol	Good strength
Color	None

A pure extract of good strength.

ADULTERATED CANDIES.

A few of the candies found on sale in the grocery stores were examined to see to what extent they were colored with coal tar dyes. In this preliminary examination no attempt was made to determine other adulterants. The method employed was the method of the Association of Official Agricultural Chemists and known as the method of Sostegni and Carpentieri for determining the coal tar coloring of matters by double dying wool. The dyed woolen cloth for each sample found to contain coal tar dye is now on file at the Chemical Laboratory.

It is true the National Association of Confectioners of the United States has published a list of forbidden and permitted colors for the guidance of confectioners. This list is certainly not based on the known physiological action of the dyes and if the reader will see what has already been said regarding the use of these products on page 120 it will be seen there is good reason for prohibiting their use in a product like candy that should be classed as a food product, when used to such an extent as it is at the present time. Again, young children are the largest consumers of the cheaper grades of candy and such candies are the ones found most generally highly colored with coal tar dyes. Altogether 28 kinds and samples of candies were examined and of these, 14 or 50 per cent. were found to contain coal tar colors.

No candy was examined unless the sellar could give the name of the producer. The following is a brief summary of the data for the candies examined:

Of the candies produced by Roach & Co., of St. Paul, Minn., eight samples were examined, four of these or 50 per cent. were found to be colored with coal tar dyes. The colored ones included the kidney bean shaped small red candies highly colored; the strawberry candies; the brown kidney bean shaped candies, and the wintergreen lozengers.

Of the candies produced by Franklin, MacVeagh & Co., Chicago, Ill., five samples were examined, and in each case all the red colored samples were highly colored with coal tar dyes. All other colors were found to be free from coal tar dyes.

Of candies produced by C. A. Everhart & Co., Fargo, N. D., 15 samples were examined and nine, or 60 per cent., were found to be colored with coal tar dyes. The colored kinds included the little red tablet candies, the black balls or marbles, the yellow bean shaped kind, the small red balls and some stick candy.

CREAM OF TARTAR.

Five samples of cream of tartars purchased in bulk have been examined. Two of these were found to contain no tartrates whatever, being alum and phosphate compounds, costing but very little, but being sold at 40 cents per pound. The following description applies to the samples examined:

No. 64 Cream Tartar in bulk.
Purchased from T. E. Yerxa, Fargo, N. D.
No. 103 Cream Tartar in bulk.
Purchased from C. J. Calmer, Fargo, N. D.
No. 149 Cream Tartar in bulk.
Purchased from Fargo Grocery Co., Fargo, N. D.
No. 157 Cream Tartar in bulk.
Purchased from O. S. Hadeland, Fargo, N. D. Producer, J. H. Bell & Co., Chicago, Ill.
No. 170 Cream Tartar in bulk.
Purchased from E. A. Perry, Fargo, N. D.

Of the above No. 149 was found to contain:

	Per cent.
Lime CaO	25.45
Sulfuric acid SO_3	29.19
Phosphoric acid P_2O_5	16.43
Alkalies	2.50

This sample contains no cream of tartar whatever.

No. 157 was found also to be an alum phosphate powder containing no cream of tartar.

These results show that 40 per cent. of the so-called cream of tartars were found not to be adulterated but pure substitution of very cheap and inferior products for the genuine article.

BLACK PEPPER.

Plack pepper (*Piper nigrum*) is the immature sun-dried berry of a climbing plant, one of the pepperworts, a native of the East Indies. The plants grow to a height of 8 to 12 feet, bearing berries or "drupes" green in color and later turning red. When they are picked and on drying in the sun, they shrivel and turn black.

Winton has proposed the following standard for pure black pepper:

	Per cent.
Ether Extract (at 100° C) not less than	6.50
Fiber, not more than	16.00
Ash, not more than	6.50
Sand, not more than	2.80

Adulterants. Ground olive stones commercially known as "poiurette" and "pepperette" are extensively used as adulterants.

Sorghum, millet, and coriander seeds are quite generally employed. Cayenne pepper is added to give pungency to the adulterated pepper. Ground cocoanut shells, pepper shells, wheat products, buckwheat hulls, mustard shells, and long pepper are used as substitute products.

White pepper is the black pepper with the shell removed or decorticated.

No. 7. Black pepper, bulk. Purchased of T. E. Yerxa, Fargo. Cost 30 cents per pound.

No. 5. Amboyna pepper, ¼ lb.; cost 10 cents. Mfg. by Yerxa Bros., St. Paul, Minn. Purchased of T. E. Yerxa, Fargo.

No. 83. Penang Shot pepper. Warranted absolutely pure. Mfg. by Reid, Murdoch & Co., Chicago, Ill. Purchased of C. J. Calmer, Fargo. Cost 15 cents per 4 ounces.

No. 105. Black pepper, bulk. Mfg. by Reid, Murdoch & Co., Chicago, Ill. Cost 40 cents per pound.

No. 1. White pepper, bulk. Purchased of T. E. Yerxa, Fargo. Cost 40 cents per pound.

No. 110. White pepper, bulk. Mfg. by Reid, Murdoch & Co., Chicago, Ill. Cost 50 cents per pound. Purchased of C. J. Calmer, Fargo.

No. 168. Tillmann's black pepper. Producers, Tillman & Bendel, San Francisco. Sold by E. A. Perry, Fargo.

No. 154. Black pepper, bulk. Producer, J. H. Bell & Co., Chicago, Ill. Purchased of O. S. Hadeland, Fargo.

No. 153. White pepper, bulk. Sold by Fargo Grocery Co.

BLACK PEPPER.

	No. 7	No. 5	No.154	No. 83	No.105	No.168
Water	4.90	5.46	8.45	7.27	9.42	7.69
Ash	9.93	7.22	2.66	4.16	4.54	2.66
Ether Extract	5.19	7.85	6.97	7.96	7.92	8.19
Fiber	31.99	28.90	18.97	13.20	14.05	7.95
Alcoholic Extract	4.51	8.68	8.94	9.58	4.54	8.94
Nitrogen	1.49	1.96	2.12	2.38	2.28	2.16

WHITE PEPPER.

	No. 1	No. 110	No. 153
Water	7.79	10.48	6.53
Ash	5.41	1.14	1.02
Fiber	9.20	3.95	2.36
Ether Extract	8.46	7.39	4.30

Alcoholic Extract	9.43	8.60	5.45
Nitrogen	1.80	1.87	2.01

No. 7 with 9.93 per cent. of ash was found to contain 5.43 per cent. of sand, as against 2 per cent. the standard.

No. 1 is also far from pure, containing much that should not be in white pepper of good grade. The only black pepper in the above that could be classed as meeting the requirements is No. 168. Of the others, all have a large excess of the shell and other foreign adulterants.

CLOVES.

Cloves (*Eugenia aromatica*) are the unexpanded flower buds of a small evergreen tree, a native of the Molucca Islands. They are extensively cultivated in the Philippines, South India, Zanzibar, and the Antilles. The tree blooms twice a year and the buds are sun dried.

Adulterants. Cloves are largely adulterated with clove stems, ground cassia, cassia buds, ground cereals, and exhausted cloves. Pure cloves should not contain less than ten per cent. Volatile oil, not less than four per cent. non volatile ether extract, nor more than eight per cent. of ash.

No. 112. Cloves, bulk, ground. Purchased of C. J. Calmer, Fargo. Cost 25 cents per pound.

No. 8. Cloves ground by H. B. Straight Co., St. Paul, Minn. Purchased of T. E. Yerxa, Fargo, N. D. Cost 10 cents.

No. 18. Cloves ground, bulk. Purchased of T. E. Yerxa, Fargo. Cost 8 cents.

No. 161. Bell's cloves. Producer, J. H. Bell & Co., Chicago, Ill. Sold by E. A. Perry, Fargo.

No. 145. Cloves, bulk. Sold by Fargo Grocery Co.

	No. 18	No. 8	No. 145	No. 112	No. 161
Water	8.01	13.02	13.18	14.28	17.52
Ash	4.26	6.61	5.95	6.45	5.64
Ether Extract ..	5.54	11.49	9.39	8.77	7.74
Alcoholic Extract	9.06	14.91	12.07	14.38	19.83
Nitrogen	3.15	1.79	1.59	1.45	.98
Fiber	20.63	13.33	9.39	14.51	12.54
Volatile Oil	1.86	6.88	4.75	2.57	11.53

Number 161 is the only sample that can be classed as pure cloves. The Volatile oil should constitute from 10 to 20 per cent. of the cloves. Samples Nos. 18 and 112 have lost nearly all of the true volatile oil and would be classed as very inferior products.

MUSTARD.

Mustard is the flour made from the seeds of *Brassica nigra* (black mustard) and *Brassica alba* (white mustard). Usually a part of the mustard oil is removed before grinding. In order to remove the husks before grinding the seed are powdered and pressed through a sieve.

The following data from A. O. A. C. may be taken as guide:

	Per cent.
Moisture	3 to 8
Ash	4 to 7
Ether Extract	31 to 37
Fiber	4 to 6.5
Water Extract	30 to 38
Sulphur	1 to 1.6

Commercial mustard is often a mixture of the two varieties. Mustard contains no starch.

Adulterants. Flour, either rice or wheat is a common adulterant. Gypsum has been found occasionally as an adulterant. Tumeric is largely used to give color and even coal tar dyes, especially Martinus' yellow, and Naphthol yellow S, also lead chromate have been reported.

No. 19. Mustard, bulk. Purchased from T. E. Yerxa, Fargo. Cost 30 cents per pound.

No. 9. Mustard Mfg. by N. B. Strait Co., St. Paul. Warranted pure.

No. 13. Colman's Mustard, Mfg. in England. Sold by T. E. Yerxa, Fargo.

No. 111. Mustard, bulk. Mfg. by Reid, Murdoch & Co., Chicago. Purchased of C. J. Calmer, Fargo. Cost 40 cents per pound.

No. 166. Tillmann's mustard, produced by Tillman & Bendel, San Francisco. Purchased from E. A. Perry, Fargo.

No. 156. Mustard, bulk. Produced by J. H. Bell & Co., Chicago. Sold by O. S. Hadeland, Fargo. Cost 40 cents per pound.

No. 162. Bell's mustard, produced by J. H. Bell & Co., Chicago. Sold by E. A. Perry, Fargo.

No. 150. Mustard, bulk. Sold by Fargo Grocery Co.

No. 78. Mustard, Mfg. by Reid, Murdoch & Co., Chicago. Purchased of C. J. Calmer, Fargo. Cost 15 cents per 4 ounces.

	No. 19	No. 9	No. 13	No. 111	No. 156
Water	5.44	4.14	1.76	6.69	6.21
Ash	3.58	6.01	4.16	5.34	6.68
Ether Extract	8.09	18.34	38.65	17.15	17.20
Fiber	2.69	4.60	2.93	2.96	3.26
Alcoholic Extract	11.66	19.28	21.30	25.34	23.43
Nitrogen	2.61	6.93	5.25	6.56	6.52
Water Extract	17.30	31.06	27.30	.....	34.68

	No. 78	No. 166	No. 162	No. 150
Water	4.64	5.97	7.21	8.97
Ash	5.08	3.68	5.92	5.91
Ether Extract	17.67	15.99	17.39	19.22
Fiber	2.72	7.83	2.24	1.79
Alcoholic Extract	25.74	24.36	21.2	25.70
Nitrogen	6.85	6.72	6.52	6.10
Water Extract	22.86	35.08	32.36	35.16

Mustard No. 19 was heavily adulterated with flour and colored with Tumeric.

No. 156 contained considerable foreign starch.

No. 9 is not wholly pure but contained considerable of the husk.

ALLSPICE.

Allspice or pimento (*Pimento officinalis*) is the dried nearly ripe berry of a small tree, a native of the West Indies and is extensively grown in Jamaica.

Adulterants. While the price of allspice is so cheap it is less subject to adulteration than most other of the spices, nevertheless cases are reported. Ground clove stems are commonly added, also ground cocoanut shells which closely resemble ground allspice.

Allspice should contain not to exceed 6 per cent. of ash and from 3 to 4 per cent. of Volatile oil.

No. 20. Allspice, bulk. Cost 8 cents. Purchased from T. E. Yerxa, Fargo.

No. 12. Allspice. Mfg. by Batavia Preserving Co., Batavia, N. Y.

No. 10. Jamaica Allspice. Mfg. by Yerxa Bros., St. Paul, Minn. Cost 10 cents per 4 ounces. Purchased from T. E. Yerxa, Fargo.

No. 76. Allspice, select, ¼ lb. Cost 50 cents. Mfg. by Reid, Murdoch & Co., Chicago, Ill. Purchased from C. J. Calmer, Fargo.

No. 165. Tillmann's Allspice. Producers, Tillman & Bendel, San Francisco. Sold by E. A. Perry, Fargo.

No. 155. Allspice, bulk. Producers, J. H. Bell & Co., Chicago. Sold by O. S. Hadeland, Fargo. Cost 40 cents per lb.

No. 163. Bell's Allspice. Producer, J. H. Bell & Co., Chicago. Sold by E. A. Perry, Fargo.

No. 148. Allspice, bulk. Sold by Fargo Grocery Co.

	No. 20	No. 12	No. 10	No.155	No. 76	No.165
Water	6.15	9.27	4.89	7.85	5.24	9.02
Ash	3.53	4.51	4.88	3.22	3.90	4.25
Ether Extract	5.16	10.34	8.36	6.41	6.61	9.90
Fiber	14.34	23.05	24.85	23.87	22.22	20.64
Alcoholic Extract	7.92	15.56	11.01	9.18	9.44	12.05
Nitrogen	3.19	1.06	1.30	1.79	1.60	1.06

	No. 163	No. 148
Water	8.19	8.63
Ash	4.29	3.68
Ether Extract	8.36	6.29
Fiber	21.31	16.52
Alcoholic Extract	13.90	10.53
Nitrogen	.95	1.68

CINNAMON AND CASSIA.

Cinnamon (*Cinnamonum Zeylanicum*) is the inner bark of the young branches of a small tree cultivated mainly in Ceylon. This product is now rarely found outside of the drug trade.

The cinnamon of the grocery trade is Cassia, or Chinese "Cinnamon," is thicker than true cinnamon and covered with more or less cork-like material. Saigon Cassia or "cinnamon" is much stronger than the others but less delicate. There is a marked difference in the commercial grades of cinnamon, also in the cost.

Adulterants. Inferior grades are often substituted, also extracted cinnamon and cereal products. Various kinds of bark, nut shells, oil cake, sand and sawdust. Cinnamon should not contain more than 5 per cent. of ash.

No. 11. Cinnamon. Mfg. by H. B. Straight Co., St. Paul, Minn. Purchased of T. E. Yerxa, Fargo. Cost 10 cents per 4 oz.

No. 14. Bulk Cinnamon. Purchased from T. E. Yerxa, Fargo. Cost 30 cents per pound.

No. 85. Cinnamon. Mfg. by Reid, Murdoch & Co., Chicago, Ill. Cost 15 cents per 4 oz. Purchased of C. J. Calmer, Fargo.

No. 88. Monarch Ceylon Cinnamon, same as last, cost 10 cents per package; warranted absolutely pure.

No. 167. Tillmann's Cinnamon. Producer, Tillman & Bendel, San Francisco. Sold by E. A. Perry, Fargo.

No. 152. Cinnamon, bulk. Sold by Fargo Grocery Co.

	No. 11	No. 14	No. 85	No. 88	No.167	No.152
Water	6.64	5.79	8.88	9.24	7.37	7.81
Ash	3.63	4.25	2.87	3.66	3.68	6.06
Ether Extract	2.62	2.66	2.37	2.13	6.46	3.21
Fiber	25.80	29.00	21.49	23.54	24.43	26.81
Nitrogen	.84	.70	.73	.87	.64	.67
Alcoholic Extract	11.81	8.54	8.94	14.02	5.43	10.11

CAYENNE PEPPER.

Cayenne pepper is the ground pods of several species of *Capsicum.* The commercial products are mainly derived from *Capsicum annuum* or *fastigiatum.* The latter, called African or bird pepper, is the more common in this country has scarlet red pods. The entire pod is ground, furnishing a red brick powder with a characteristic odor and most intensely pungent taste. Cayenne pepper contains no starch.

The following has been given as a standard for the pure product:

	Per cent.
Moisture	2 to 10
Ash	5 to 10
Fiber	10 to 18

Ether Extract	10 to 30
Alcoholic Extract	25 to 45
Nitrogen	1.7 to 2.2

Adulterants. Rice flour has been used considerably as an adulterant. Brick dust and iron oxide have been found as an adulterant. also red lead for giving color. The presence of flour from any of the cereals is easily detected from the presence of starch. Red coloring matter of coal tar origin is reported in one Minnesota sample, where wheat flour had been used as an adulterant.

No. 6. Royal Cayenne Pepper. manufactured by Dwinell, Wright & Co. Boston. Guaranteed absolutely pure.

No. 3. Bulk pepper purchased from T. E. Yerxa. Fargo.

No 4 Yerxa's Natal Pepper. Mfg. by Yerxa Bros., St. Paul Minn.

No. 64. Tillman's Cayenne Pepper. produced by Tillmann & Bendel. San Francisco. Sold by E. A. Perry. Fargo. Cost 10 cts.

No. 129. Select Cayenne Pepper. produced by Bell, Conrad & Co., Chicago. Sold by Fargo Grocery Co.

	No. 6	No. 3	No. 4	No. 164	No. 129
Water	5.78	3.80	4.75	5.86	6.70
Ash	6.37	7.77	6.86	6.68	8.99
Fiber	24.65	25.92	28.25	22.57	15.27
Ether Extract	19.36	17.90	17.41	20.05	23.59
Alcoholic Extract	27.50	22.50	20.80	28.47	13.16
Nitrogen	1.75	2.27	2.05	2.05	2.52

None of the peppers above can be considered as free from adulterants judging from the above standard. and none of them were found to be wholly pure in the chemical examination.

GINGER.

Ginger is the rhizome of *Zingiber officinal*, a native of India. Our supply comes mainly from Jamaica, although China, Bengal, Africa and Japan produce large quantities. The true Jamaica product gives us the best, the African grown the poorest ginger. Ginger of commerce may appear in two forms, "coated" and "scraped" ginger.

Adulterants. The most common adulteration is the use of exhausted ginger, that from which the active principle has been extracted for use in ginger ale, ginger extract, etc. Tumeric, ground husks, shells, flour, and roasted peas and cereals, are also sometimes substituted. Ginger should not contain above 8 per cent. of ash for the "coated" and 4.5 per cent for "scraped" ginger unless lime or gypsum have been added.

Allen and Moor give the following guide by which to judge the purity of gingers:

	Jamaica.	Cochin.	African.
Moisture	13.9-12.7	13.5	15.9
Total Ash	3.9- 3.2	3.8	3.6
Soluble Ash	3.0- 1.7	2.0	2.2
Water Extract	14.4-12.2	8.6	10.8

No. 17. Ginger, bulk. Purchased from T. E. Yerxa, Fargo. Cost 30 cents per pound.

No. 16. Ginger. Mfg. by Yerxa Bros., St. Paul, Minn. Cost 10 cents per 4 ozs. Purchased of T. E. Yerxa, Fargo.

No. 108. Ginger, bulk. Purchased from C. J. Calmer, Fargo. Cost 30 cents per pound.

No. 102. Borneo Ginger. Mfg. by Reid, Murdoch & Co., Chicago, Ill. Cost 15 cents per 4 ozs.

No. 169. Tillmann's Ginger. Produced by Tillmann & Bendel, San Francisco. Sold by E. A. Perry.

No. 151. Ginger, bulk. Sold by Fargo Grocery Co.

	No. 17	No. 16	No.108	No.102	No.169	No.151
Water	7.10	4.63	7.94	6.46	8.44	9.79
Ash	3.43	5.08	5.16	3.86	4.40	6.98
Ether Extract	5.54	6.87	4.10	4.12	4.20	5.19
Fiber	4.45	7.35	5.74	4.33	2.88	6.05
Water Extract	8.16	13.38	13.03	15.74	6.40	13.48
Alcoholic Extract	7.06	7.58	6.12	7.44	5.29	5.50
Nitrogen	1.91	1.09	1.88	2.07	1.46	1.34

Numbers 17 and 169 yielded such a low per cent. of water extract that it is safe to assume these two have been extracted and the exhausted product sold as ginger. Number 102 is two and one-half times as valuable as No. 169, judged from the amount of water extract.

MACE.

Mace is the dried mantle of the fruit of the nutmeg tree, grown extensively on the Banda Islands. Mace should contain at least 3 per cent of Volatile oil, nor more than 35 per cent. of extract.

Adulterants. Talso or Bombay mace, containing neither the fragrance nor the taste of true mace, is frequently substituted according to Leffmann.

No. 15. The following sample of mace, marked strictly pure, was purchased of T. E. Yerxa, Fargo:

	Per cent. No. 15
Water	9.37
Ash	2.48
Ether Extract	26.98
Fiber	4.25
Nitrogen	1.15
Alcoholic Extract	26.64

Water Extract gives strong reaction for starch.

Alcoholic Extract yellow, made alkaline it turns red.

This product is not pure.

CEREAL FOOD PRODUCTS.

A few food products recently examined are here described and the analytical data given in an accompanying table.

No. 89 Dakota Wheat Hearts.
Claimed to be made from Scotch Fife Wheat grown in the Northwest.

No. 79 Fruen's Best Wheat Flakes.
Made by the Fruen Cereal Co., Minneapolis, Minn.
Claimed to be made from Pacific Coast White Wheat.

No. 28 Force. Manufactured by the Force Food Co., Buffalo, N. Y.
Claimed to be prepared from the whole of the wheat and barley malt.

No. 75 Purina Health Pancake Flour.
Produced by Purina Mills, St. Louis, Mo.
Claimed to be produced from whole wheat flour, corn flour, salt, phosphate and soda.

No. 73 Zenith Oats. Produced by R. H. Heath & Sons, Fort Dodge, Iowa.

No. 86 Century Health Pancake Flour. Manufactured by Purina Mills, St. Louis, Mo.
Claimed to be made from gluten, whole wheat flour and corn flour.

No. 154 **Pillsbury's** Vitos. Manufactured by Pillsbury-Washburn Flour Mills Co., Minneapolis, Minn.

No. 80 Cook's Flaked Rice. Produced by the American Rice Food & Mfg. Co, Matawan, N. J. The claim is made that flaked rice contains 87 per cent. nutriment, beef 45 per cent. and potato 21 per cent. One pound of flaked rice contains 21 per cent. more life-giving nourishment than a pound of beef and a pound of potatoes combined. Now, in the light of the analysis, such statements are wholly misleading, intended to deceive, and therefore false. The product may be a good one, but it is not what its makers would try to have the readers believe it is.

No. 270 Malta Vita. Manufactured by the Malta Vita Pure Food Co., Battle Creek, Mich.

Claimed to be made from selected wheat, barley, malt, and other nutritive ingredients. Several absurd claims are made and misleading statements are printed on the packages. We may mention the following: "Malta Vita is the only food containing all the elements in their proper proportions necessary to support the human system, the phosphates or brain makers, the nitrates or muscle makers, the carbonates or heat makers." A little inquiry would have shown the manufacturers that nitrates are plant food, poisonous to man, while the carbonates are mineral products that furnish no heat whatever. Such statements are absurd; while the product may be a valuable food, the statements of the manufacturers are not evidently to be relied upon.

291. Nutrium is the evaporated residue from skim milk.

3[illegible]8. Milk flour is similar to the last product. It is made by [illegible] Milk Food Co., of New York.

No.	Water	Ash	Ether Extract	Crude Fibre	Proteids N×6.25	Nitrogen Free Extract
[illegible]9 Wheat Hearts ...	9.36	1.31	2.25	1.16	17.34	77.94
[illegible]9—Wheat Flakes ..	6.37	1.64	2.16	1.82	11.69	82.69
28—Force	7.17	3.21	2.31	2.39	11.93	80.16
A—Plasmon	Dry	7.72	.28	....	70.16	21.84
B— Plasmon Biscuit.	Dry	1.78	10.02	....	19.68	68.52
[illegible]3—Zenith Oats	8.44	1.80	6.22	1.26	18.00	64.26

75-Purina Pancake Fl.	10.50	5.61	1.44	.92	10.16	71.37
86— Century Health Pancake Flour	10.26	5.44	1.24	.61	10.13	72.32
154— Pillsbury's Vitos	8.47	.38	.96	.24	12.03	77.91
80—Flaked Rice	10.17	.44	.24	.46	7.19	81.51
270—Malta Vita	3.47	2.63	1.72	2.09	12.06	78.03
291—Nutrium	5.22	4.52	4.13	....	36.67	53.44
328—Milk Flour.. ..	4.39	4.06	1.10	....	22.66	67.59

Pillsbury's Vitos. The analysis given on the package calls for 16.64 per cent. of proteids. Analysis of a sample bought on the open market we find Vitos to contain 12.03 per cent. proteids, or 4.61 per cent. less than is claimed for the product.

Fruen's Wheat Flakes and Wheat Wafers are evidently one and the same, since the two sides of the package give different names. The statement that the indigestible matter has been entirely removed is shown by this analysis to be false.

GENERAL STATEMENTS.

The data presented in this bulletin plainly indicates that the law to prevent food adulteration is not being complied with on the part of the producers whose goods are being sold in this state.

The law should be so amended as to make it the duty of some officer to inspect the food products offered for sale in the state. When food products are found to be adulterated and after due warning to those not complying with the law all parties found violating it should be prosecuted by the state's attorney of the district on proper certification of the facts by the inspecting officer. This work could be most economically done if made a part of the work of the Government Experiment Station, as is now the case in many of the other states.

The writer believes it little less than criminal that food products should be allowed to be sold in the state containing such large quantities of chemical preservatives and coal tar dyes, as have been found in some of the canned goods, catsups, and preserves.

From preliminary examinations it is believed that many food products not given in the following lists will be found to contain equally as large amounts as these chemical preservatives.

From examination of vinegars sent to the writer for analysis from various parts of the state, it would seem that but very little of the product being sold as cider vinegar was really made from apples.

Samples of milk and of cream sold in the state have been found to contain formaldehyde. As already shown milk containing formaldehyde certainly can not be a safe food for infants and invalids. The use of formaldehyde is wholly unnecessary for preserving milk, and any person using it for that purpose should be punished to the full limit of the law.

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 54.

I. ABORTION IN CATTLE.
II. SCOURS IN NEW-BORN CALVES.

By DR. L. VAN ES.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
December, 1902.

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I. ABORTION IN CATTLE.

BY DR. L. VAN ES.

When expulsion of a foetus takes place at such a stage of pregnancy that it is not capable of being kept alive, we speak of abortion.

Taking in consideration the causes, we may divide abortion into three distinct classes.

I. Abortion caused by mechanical injury or as a consequence of some other acute disease.

II. Abortion due to the eating of mouldy food, of plants being affected with a fungoid disease or of plants which have a specific action on the uterus.

III. Abortion due to disease of the mucous membrane of the uterus and foetal membranes, and which is caused by the action of a specific micro-organism.

Of those three types of the disease, the latter is perhaps of the greatest importance to the stock growers of this state, as great losses are caused by it and, as we will see later, it is one of the most troublesome disorders to get rid of.

Nevertheless, it will be useful to briefly discuss the two former types, so as to enable stockmen to distinguish between all those forms readily and give them the means in hand to begin active measures of prevention at an early stage, should the abortion in their herds prove to belong to the infectious type.

I. The first type, more commonly known as sporadic abortion, results usually from some severe mechanical injury such as a fall, or by cows hooking or riding one another. In those cases death of the foetus, or some lesion of its envelopes, precedes its expulsion, as its direct cause. There are no preliminary symptoms, and the first indication of something being wrong comes in the shape of a report that such and such a cow has slipped her calf. No previous springing of the udder or vaginal discharge occurs as a sign, by which we may anticipate the coming abortion. Cases of this class occur singly and taking them as a whole are more commonly seen in animals which are in the more advanced stages of pregnancy.

II. The second class of cases are produced by the ingestion of food stuffs, which are affected with certain fungoid diseases:

Of those the ergot of rye and corn smut are typical representatives, but as a large number of our wild and cultivated grasses are not exempt from those diseases, it is readily understood, that considerable damage may be done in this manner.

When we are confronted with abortion of this sort, the principal characteristic of it is, that a greater number of animals, kept under similar circumstances abort within a short space of time. After a change of feed or pasture the disease will again disappear. In certain parts of Europe, this type of abortion is common, when the hay has been improperly cured, owing to prolonged rainy seasons. In such instances the abortion is probably due to certain fungi which grow on the partially dried hay.

Besides those causes, abortion of this type may also be produced by the eating of plants having a specific action on the womb There are certain evergreens having this action and the expulsion of the foetus is produced by violent uterine contractions. Abortion of this type affects animals during all stages of pregnancy; as in sporadic cases, there are no preliminary symptoms, while the secretion of milk commonly remains scant and never has the colostrum-like appearance like that seen in cases of specific abortion.

In order to dispose of the subject of non-specific abortion, it may be well to say that the only treatment possible of application is a preventative one in the second type of the disease. This consists of a change of food, substituting the mouldy or diseased article for one in better condition. As in those cases we are commonly confronted with an accomplished fact, it would be out of place to recommend any medicinal treatment.

III. Specific or contagious abortion must be discussed far more thoroughly, as in this disease we have one of grave economic importance. It is readily introduced into a herd, slow but sure in its action, and once having a foothold, it is exceedingly difficult to get it under control. It strikes with equal force all branches of the cattle industry at the most vital point, viz., the propagation of a breed or herd. It also causes a large reduction in the yield of milk in herds kept for dairy purposes.

It is evident from the numerous inquiries received at this station, that the disease is by no means uncommon in this state, and it may be well for our stockraisers not to disregard its presence.

While the disease attacks mares, sheep and goats, it is more commonly witnessed in cattle, but the first animals must not be lost sight of, as they may be able to carry the disease from place to place.

The disease commonly makes its way into a healthy herd in a very insidious manner, and for this reason it often is impossible to trace its origin. Nevertheless, in the case of several outbreaks this has been done and often it was found to occur after some mingling with diseased herds or animals. It also has been observed by intelligent breeders, that outbreaks of infectious abortion have followed the introduction into the herds of cows having a vaginal discharge. Whatever history an outbreak may have, it usually tends to show that contamination by diseased stock took place. Once introduced, the disease often goes on for some time before its true character becomes recognized. In the beginning of the outbreak animals abort one after another, but as there usually is some space of time between the individual cases, no alarm is felt. When the disease progresses, the disease becomes more frequent, and after it has become well established, the majority of the animals abort with great regularity.

The question now arises, will a cow keep on aborting, or will the disease finally disappear and the animal carry its calf to time? My experience with the disease leads me to believe that the latter is the case. If we have an infected herd and abstain from introducing new animals, or from allowing young animals to breed, my opinion is that the disease will ultimately disappear. The writer is, however, not prepared to say how long there would be danger for an outside animal or rather how long would infected material remain active. While in such an instance the original animals have acquired immunity, they still may be capable of conveying virulent bacteria to non-immunes.

Reindl, who had great experience with the disease in Germany, states that a special predisposition is produced by inbreeding, while he also made the observation that breeds of darker color are more resistant to the infection. I have never seen those statements corroborated, however.

Infected animals usually remain in the normal condition of health and all the phenomena of disease to be observed are those which occur shortly previous to,. during and after the act of abortion. I need not say that cows having suffered of an abortion are liable to such diseases as are characteristic of the paturient state, such as septicaemia (blood poison), inflammation of the womb etc. The writer once saw a fatal case of milk fever in a Jersey cow, which suffered from infectious abortion during the sixth month of pregnancy.

When a cow is infected and the time of expulsion of the foetus draws near, certain preliminary symptoms make their appearance. In different individuals those symptoms are present in a varying degree. In some they are very pronounced, in others scarcely to be noticed. If present, they consist of the appearance of a puffy swelling of the vulva and the tissues immediately surrounding it; at the same time the udder commences to spring. This springing of the udder, however, is never of the same degree of intensity as when it occurs under normal conditions, unless abortion takes place during the latter stages of pregnancy. The mucous membrane of the vagina at this stage commonly appears to be redder than is normally the case, and not unfrequently is marked by cordlike swellings or studded with reddish yellow or brown elevations. Those conditions would indicate that the vaginal mucosa has been involved for some time.

From the vulva issues a nasty, yellowish, mucoid or purulent discharge. Within three to six days after the beginning of those signs, the expulsion of the foetus takes place. Delivery occurs without any great effort or great inconvenience of the animal. Most commonly in cases of specific abortion, the expulsion occurs between the fourth and eighth month of pregnancy, in the great majority of cases the foetus being dead.

When abortion takes place during the earlier months of pregnancy the foetus is usually expelled enveloped in its membranes, but when it happens at a later period, the foetus comes away first and the membranes follow later. After infectious abortion it is more than common, that the placenta is retained and is only removed by putrefaction. The importance of this fact will be further brought out when dealing with the management of such cases.

After the afterbirth has been gotten rid of, a nasty. mucopurulent discharge is kept up.

Like in cases of normal births, the secretion of the udder shortly before and after abortion has the characteristics of colostrum. It may here be said that in the experience of the writer, cows aborting during the eighth month of pregnancy frequently come to a paying milking capacity, while animals aborting during the earlier stages go dry after a very short period of lactation. The contagious or infectious character of this disease has long been recognized and the fact is now well established. One can without difficulty transfer the disease from one animal or herd to another. A great number of investigators have been industriously engaged to isolate the germ producing the disease. Among the more prominent of those are Bang and Stribolt of Denmark, Franck and Brauer of Germany, Nocard and Galtier of France and Chester, Law and Moore of this country. The work of Bang is perhaps the most conclusive of all, but the results of the other investigators should not be lost sight of. In these investigations different bacteria were found and it is possible, that the disease be the result of more than one species of micro-organism. Bang isolated a very small bacillus, which he cultivated on artificial media and found, when such a culture was injected into the vagina of a non-infected animal, that abortion followed in due course of time.

The changes brought about by the presence of those germs consist first of a catarrhal condition of the vaginal and uterine mucous membrane, from there it is communicated to the foetal membranes. Bang found between the mucous membrane of the womb an abundant, colorless exudate, a dirty yellowish, tolerably thin mass, and of a slimy, lumpy consistency. In this exudate the bacillus was present in large numbers, and it was readily cultivated on artificial media.

As part of Bang's and Stribolt's experiments, we may mention that they injected such artificial cultures into the vagina of a four year old cow on the 14th of April and that she aborted on the 24th day of June. In the discharge from the uterus the same kind of bacillus was again found. Another cow which also received a culture per vagina on the same day, was killed on the 24th of June and on post-mortem showed the characteristic lesions of the mucous membrane and the foetal coverings.

This experiment not only proved the specific character of the germ but also showed that the period of incubation is quite long. Those experiments also demonstrated that the germ is capable of remaining alive for a long time outside the body; they kept the exudate of the uterus for three months on ice and at the end of that time it still contained living bacteria.

The presence of this organism between the uterine mucous membrane and the placenta, results in the death of the foetus and Bang showed that the bacillus is also contained in the internal organs of the latter. But while those investigations are of great value and quite promising as to practical results, the nature of the publication does not permit a more full discussion of them, but the question as to how infection takes place will have to be dealt with as information on this point will give great advantages when planning the means of successful prevention. The cause and nature of the disease are so that we may safely conclude that the only way for infectious material to gain entrance is by the vagina. Now let us see in what manner this may take place and give an example. A cow from an infected herd and having a vaginal discharge subsequent to a case of abortion is brought into a healthy stable or herd. The discharge containing the causative agent drops around on the premises, soiling stable, bedding, etc. Uninfected animals lay down in such and the small organisms readily adhere to the animal's quarters, from there gaining access to the genital organs. A still more probable method of infection is by the animals licking one another about the hind quarters and the genital organs, something which is frequently seen in animals running loose in corrals and pastures.

A few authors have charged the bull as being a factor in the distribution of the infection and while the writer has always firmly believed in the probability of this theory, it never was as forcibly impressed on him as after learning from various inquiries received at this station, that the disease not infrequently occurs among the range cattle of this state. There, it certainly cannot be laid to unsanitary conditions, infected stables, etc. While of course the other ways of infection cannot be entirely ignored, I hold it as very probable that infection often takes place in the same manner as in the venereal diseases of the human subject.

Bang made some observations along this line, the facts of which are as follows: A farmer in whose stable for more than seven years no cases of abortion had been observed, loaned his bull to a neighbor in whose stable the disease was at the time prevalent. Each one of the owner's cows, which were served by this bull, aborted in due course of time. The bull was sold, the cows and the stable disinfected and the disease ceased promptly.

In the case of another farmer, fifteen cows aborted during the spring of 1897; he sold his bull and from that time until February, 1898, he borrowed a neighbor's bull which was also used by another breeder. The owner of the bull nor the third party ever had observed a case of abortion in their stable, but during 1898 the disease made its appearance in their stables, the cows in which were served after those of the first farmer, whose cattle were thoroughly infected. In a third instance two neighbor farmers owned each 25 cows and for a long time each used a bull of his own. One of them never had any abortion among his cattle, while the disease had existed for three or four years among the cows of the other. The first farmer, whose cows were healthy, sold his bull and used his neighbor's for serving 13 cows; these 13 cows aborted, while the others which had been served before the sale of the bull carried their calves to time. The stable was disinfected and the disease stopped.

Those observations certainly show that the bull must be regarded as a certain carrier of the abortion bacillus.

Having discussed some of the general features in connection with this disease, some attention should now be paid to the means we may adopt towards eliminating the disorder from our herds. The disease being strictly localized to the mucus membrane of the genital organs and the foetal envelopes, it is evident that a general internal medication cannot be of much or any benefit. In spite of the fact that dairy and stock papers are crowded with advertisements of "sure cures" for abortion, one will find that none will have any effect whatever in checking the disease and owners of infected animals may as well save their money for better purposes. The writer has seen several of such remedies tried, including the much praised Fluid Extract of Black Haw (Viburnum prunifolium), but never was able to observe any benefit from such treatment.

When a pregnant animal is infected or shows the signs of approaching abortion, there is no medicine which will prevent this from taking place. We are compelled, then, to look for other means to get rid of this nefarious disease, and the only thing we can do is to make attempts at prevention. Prevention, in order to keep our herds free of the infection and prevention in order to confine abortion to certain individuals and check the spreading of the disease in case the infection has been introduced into the herd.

How now to keep the disease out of our stable and herds? This can be simply answered by saying—keep away infected animals. In order to accomplish this, one should make sure that, in buying new stock it shall not come from an infected herd. An animal coming from such a herd must be regarded as infected and should not be allowed to come in contact with non-infected animals. In buying cattle of uncertain origin, care should be taken that no animal is introduced that shows any trace of vaginal discharge. Before introducing a strange bull into the herd, it will be safest to subject him to a thorough disinfection, following the direction given at another place. The bull being probably the most important means of scattering the infection, owners of non-infected herds should be cautious that their bulls be not used to serve infected cattle, while those who do not own a bull themselves should also be prudent when patronizing bulls being kept for public use.

While paying attention to all those details we must not lose sight of the fact that man himself may be the transmitter of infection. An instance of this came under the observation of the writer, in which a man who had removed the afterbirth from a cow after abortion, promptly infected some other cows, which he treated in a similar manner.

When the infection is once introduced into a herd, it becomes a more difficult matter to eradicate the disease and it is quite a test of persistence on the part of the stock owner, before the trouble is under control and before abortions cease to occur. Before attempting the stamping out of the disease one should realize that such cannot be accomplished in a short space of time, but that it is sometimes a matter of months, if not years. This much, however, can be said, that the more thorough and systematic we are in our attempts, the sooner the desired results will be obtained.

The treatment indicated, when a herd once has become infected, includes the following points, the plan, however, being subject to changes necessary to meet local conditions.

I. Destruction of the foetus and afterbirth of animals having aborted.

II. Disinfection and isolation of such animals.

III. Disinfection of stable and premises.

IV. Disinfection of animals having been exposed to infection.

V. Disinfection of the bull.

VI. Such measures as tend to prevent reinfection, including sanitary care.

After the expulsion of the foetus and its membranes, no time should be lost in their destruction. They are thoroughly infected and may be a means of contaminating other animals. Wherever such is possible they should be burnt at the place where they are found. When burning cannot be done they should be buried deep enough to prevent dogs or other animals from interfering. In case it is necessary for those substances to be removed to some other place, care should be taken that no infectious material be scattered about (such as blood, pieces of membrane, etc.).

Our attention is next directed toward the cow herself. When confronted with infectious abortion in our herds, we should have sufficient room, away from our other stables, where aborting animals can be cared for during the period when a vaginal discharge is present. It will be noticed, that in a number of cases the afterbirth is retained and our first efforts should be directed towards its removal.

While in cases of retention of the afterbirth, after normal labor, it is better to wait a day or two, in abortion cases, it better be done quite soon. The removal of the placenta being quite important, some short directions are given for those who are not familiar with the operation.

In cows the foetal membranes are attached to the wall of the uterus by means of button-like bodies, known as the cotyledons. Those are connected with the uterus by means of thin stems and on their surfaces the placenta is fastened. When manual removal of the afterbirth is necessary, we simply peel it from those little buttons with our thumbs, while we hold them secure by taking the stem between our index and middle fingers. Of those cotyledons there are a large number and one by one they are required to be detached from the placenta, using care that they be not torn loose from the womb. While doing this a gentle traction should be exerted on the part hanging out of the vagina by the hand not engaged in the uterus. When the last one is detached, the afterbirth will come away, and while we have our hand in the uterus the first disinfection of that organ should be undertaken. This is done by means of an antiseptic solution applied with an irrigator. (To be described later.) Solutions recommended for this purpose include all known antiseptics, but a weak solution of iodine has given the best results in the experience of the writer. Mix one ounce of tincture of iodine with one ounce of glycerine and add the mixture to one gallon of warm water. When flushing out the uterus for the first time a liberal quantity of solution should be used (about two gallons). This being completed, the hind quarters, tail and external genital organs must be cleansed with water and soap and washed with a solution of corrosive sublimate in water (1-2500), * The irrigation of the uterus is to be repeated every other day, with less fluid (2 to 3 quarts) and until the womb has closed, so as to no longer admit of an easy introduction of the tube. The animal should be kept in the isolated stable or pasture, until the vaginal discharge has disappeared; this usually lasts about two weeks when the cases are well treated, but much longer when they are neglected. It is very advisable not to breed such cows for some time, in order to give the organs a sufficient time to be restored to their normal condition.

Infectious abortion once being present on the premises and preventive measures being decided on, the disinfection of the stable should be carried on with some degree of thoroughness.

All litter, straw, etc., must be removed and either be burnt or scattered over the fields, where disease germs will soon perish. Drainage of the stable should be repaired or established. All loose

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*A very convenient way of making such solutions is by means of sublimate tablets which now can be had at any drug store. Those tablets contain just enough sublimate so that one of them to a pint of water will make a solution 1.1000. In order to make a 1.2500 solution we dissolve one tablet to 2½ pints of water.

dirt being removed, the stable should now be scrubbed with water and lye, rinsed with clean water and sprinkled with a solution of corrosive sublimate (1-1000) a 1 per cent solution of sulphuric acid, or a 1 per cent solution of formaldehyde (2½ gallons of formaldehyde of 40 per cent to 100 gallons of water). After disinfection has been completed, the stable should be thrown open to sun and air, while a good coat of whitewash may be of advantage. Knowing that the disease is abroad among our cattle, we must make some effort to keep it confined to certain individuals, and while we are unable to say which animal is infected or not at the time, it is safest to include all pregnant cows into the treatment to be given. Our efforts in this line consist of the disinfection of the hind quarters, tail and external genital organs and that of the vagina. When first beginning this line of treatment, the external parts should be washed every other day and the vaginal disinfection should be done twice a week. When a few applications have been made, all those measures need not be taken quite as often.

It will be needless to say that those precautions can only be of avail before the infection has gained entrance to the cavity of the uterus. Once there it is beyond our range, and abortion will take place in spite of all our efforts.

External disinfection consists of washing the parts with water and soap and rinsing them afterward with a corrosive sublimate solution, (1-2500). For vaginal disinfection, irrigations with a one-half per cent carbolic acid solution are to be recommended. (5 oz. of carbolic acid to 8 gallons of warm water). A good irrigator can be made from a tin can, provided with a faucet (such as are used by dairymen); a piece of rubber tubing can easily be attachèd to this, while the nozzle is joined to the tubing. The nozzle being the part introduced into the vagina, should be made in a suitable way. It must be at least 12 inches long, made out of brass pipe ⅜ inches thick curved near the end and the point being blunt or bulbous in order not to injure the soft parts. A metal mare catheder, as sold by instrument makers, makes an excellent nozzle. If the nozzle can be provided with a cock or cut-off, it will be found to be very convenient. These larger irrigators are especially useful when treating larger numbers of cattle. When the can is elevated the nozzle is introduced into the vagina, the stream turned on and allowed to flow until about one-half gallon to each animal has been passed in. It may be well to ascertain the length of time required for the quantity to run through at a given elevation of the irrigator so that when the douche is being applied the amount of fluid can be determined by the time of flowing. Between the irrigation of two cows the tube may be rinsed in a stronger (5 per cent) carbolic solution in order to eliminate all possible danger of transmitting infection. For the disinfection of the bull the same application can be used. The procedure is as follows: The tuft of hair near the opening of the sheath should be clipped short, the external parts of the sheath and the surrounding portion of the abdomen washed thoroughly with water and soap. Those parts are now disinfected with the sublimate solution (1-2500). Disinfection of the sheath proper is now in order and is done by introducing the nozzle of the irrigator as far as possible into the sheath and allowing the antiseptic solution to flow in. A 1 per cent solution of carbolic acid should be used here, while it is well to apply the treatment daily for two weeks and afterwards before and after serving a cow.

Few animals will offer any resistance to this treatment, but in case one should be difficult to manage, she should be placed in a tight-fitting stall or chute provided with an opening at the side, so as to permit of the necessary manipulations.

It will scarcely be necessary to point out that while all these measures are applied, such care should be taken as will tend to keep the disease confined to the affected herd and will prevent re- infection. The herd should be prevented from coming in contact with healthy cattle, the stable should be kept clean and well ventilated. When one has removed an afterbirth, soiled overalls, arms and hands should be disinfected. Overalls are best disinfected by boiling. The hands and arms must be washed with water and soap and then rinsed in the sublimate solution (1-2500). When a bad odor clings to the hands it is better to rub them with pure creoline for a few seconds and rinse it off with warm water afterwards. The measures of prevention here recommended are based on our present knowledge of the disease and can be applied by any intelligent man having experience in handling live stock. As a rule the methods oi disinfecting cattle can be carried out very well on the ordinary farm, but when treatment becomes necessary in range cattle, it is sometimes impossible to apply it. In those cases we will simply have to do the best we can. Where the cows cannot be disinfected, we may be able to treat the bulls, in fact this should be done by all means, as it is more than probable that in those cases the bull is the only factor of transmitting the disease. If this be so and the bulls treated, the infected cows would keep on aborting a few more times, but the young stock would escape and gradually the herd will outgrow the disease.

II. SCOURS IN NEW-BORN CALVES.

After infectious abortion perhaps the disease known as scours in calves (Dysentery, White Scours) is next in importance in relation to the propagation of a herd or breed. In the former the young dies before and in the latter shortly after birth.

Scours makes its appearance usually within the first few days after birth. They may even be born in a puny condition. The first evacuation of the bowels occasionally has a consistency such as is seen in cases of diarrhœa. The discharge is light colored at first, later it becomes brownish or bloody. Sometimes it is watery and flaky. At all times it has an extremely bad odor. After the animal has had a few passages, there is a great inclination towards straining. It is not long before the debilitating features of the disease become manifest; the little fellows seem to lose life, their appetite fails and they become so weak that they are scarcely able to take their milk at all. The flanks are hollow, the abdomen are drawn up, and they sometimes cry with pain. The animals are now weakened to such an extent that they cannot stand up any longer, the vitality rapidly diminishes and they soon die from exhaustion. Recovery is the exception and when such does take place the animals are often stunted for a long time to come.

When the disease once becomes established in a herd or stable, it seldom spares an animal and numerous instances are on record, in which scours had killed all calves born in a certain stable for a number of years. The changes caused by this disease are for the greater part confined to the intestines and fourth compartment of the stomach. The lesions are not characteristic, somewhat variable and often bear no relation to the severity of the disease. The intestines more commonly show a catarrhal condition, sometimes inflamed areas are present, while the blood vessels are congested and at places have actually bursted, giving rise to larger and smaller haemorrhagic spots.

The mucous membrane has a dirty grey or yellowish red color, is edematous and covered with a mico-purulent deposit. Peyer's patches are swollen and friable. In nearly all cases, dead of this disease, a condition of profound anaemia is observed, especially so in the liver, kidneys and heart; those organs generally show the degenerative changes met in all forms of septicaemia. In some cases lesion of the cord and its blood vessels are present. Nocard, investigating the disease in Ireland, found it frequently complicated with disease of the lungs, both conditions being due to the same cause.

Owing to the great economic importance of this disease, quite a few able investigators have turned their attention to it, in order to discover the cause and to devise means of stamping it out.

Nocard's investigations in Ireland and Poels' in the Netherlands are the more prominent. It seems from their findings and from the results obtained by others, that different species of bacteria may have a casual relation to the disease. Nocard found a pasteurella, Poels and Jensen a virulent colon bacillus, while the co-existence of scours and infectious abortion on the same premises has led many to believe that the two diseases are due to the same specific cause. This may, however, be an erroneous view, but as long as there is evidence that the calf may become infected while being born, it should not be cast aside without further investigation.

Whatever the nature of the infection is, it seems that it acts in a similar manner in all cases. Of course from a scientific standpoint it is to be hoped that the etiology of this disease will be fully cleared up. From a practical point of view, however, the investigations have already given us tangible results in pointing out certain methods of prevention. It matters little to the breeder whether the disease is due to a colon bacillus or to pasteurella as long as he has the means to eliminate it from his herd.

Most of those who have made a study of the disease have come to the conclusion that infected material gains entrance by means of the umbilical cord. When shortly after or during the act of delivery the cord breaks, the resulting abraded surface is as much fit to serve as an entrance for bacteria as any other wound in other regions of the body. Under normal conditions there are always bacteria present in the vagina and there is no reason why the specific organism could not be present also; they easily could adhere to the cord while birth is in progress. Infection may also take place by the stump of the cord becoming contaminated while the calf is down on the ground. From the cord and navel the bacteria gain entrance to the blood vessels and once in the blood it is rapidly disseminated throughout the body, thus reaching the intestines where they give rise to the conditions described above.

Of course the possibility of infection by the mouth is quite reasonable, but as long as animals are attacked by scours which have never taken any food, we are quite justified to regard infection by the navel as the more probable. This theory is also borne out by the fact that preventative measures directed against navel infection are usually successful.

In this disease there is but little possibility that any sort of medicinal treatment will have any influence whatever on the extremely high death rate. Aside from the fact that the infection is generalized and the changes too far advanced before diagnosis is made at all, the weak state of the animal makes the administration of medicine extremely difficult if not impossible. For the benefit of those anxious to try medicinal treatment some remedies will be mentioned, although the writer has but little confidence in their curative properties. If used at all, they should only be administered during the early stages of the disease, while the little patients still have enough strength to swallow. The following medicines may be tried:

Subnitrate of bismuth, 2 drams every four or five hours given with a little water.

Creoline, 20 drops every four hours in a little mucilage water.

Salol, from 20 to 30 grains every four hours, given in a little water.

When the calves are very weak some good port wine in tablespoon doses or brandy in teaspoon doses may frequently be given in water, well diluted.

As already stated, our attempts at medicinal treatment will seldom amount to more than a mere waste of time and material. For this reason prophylatic treatment should be applied with great promptness and thoroughness. One ounce of prevention is always worth a pound of cure and in the case of scours in new born calves it is worth a ton of it. The methods here given are largely based upon the results of the experiments of Poels, who was first to outline a rational prohylaxis of this disease. The following points must be looked after:

1. Disinfection of stable or premises.
2. Care of the cow before calving.
3. Care of the stump of the cord and navel immediately after birth.
4. Sanitary measures of a more general nature.

When the disease has found its way into a stable it will be necessary to subject the same to a thorough disinfection before we can hope to get control of the outbreak. We will not again enter into the subject at this place but refer the reader to what is said about it at another part of this bulletin under the head of Infectious Abortion. When the animals are kept in corrals and other open spaces and the disease occurs among them, it will be better to abandon such places and provide for new, clean, non-infected pens or lots in which to turn the cows which are about to calve, after they themselves have undergone disinfection. This disinfection consists of the washing of the hind quarters, external genitals, etc., with a sublimate solution (1-2500). The object is to destroy infectious material adhering to parts which are liable to come in contact with the cord during the birth of the calf. Poels goes so far as to wash out the vagina with some antiseptic solution, and no doubt this is a thorough manner of dealing with such cases. In the experience of the writer, however, external disinfection of the cows and change or disinfection of stables has always had the desired effect. Should those means, however, prove to be inadequate the vaginal douches should be applied by all means. Such cases can be treated with the solution used for the same purpose in infectious abortion. One application before and one after the animals are placed in new or disinfected quarters are quite sufficient, provided the work is done thoroughly. Birth of course takes place in the clean stable or pens which should be provided with clean straw as litter.

In order to make sure and prevent unbillical infection the stump of the cord and the parts immediately surrounding it must be cared for. This care consists of a thorough cleansing with a warm five per cent solution of creoline, after which the following mixture is applied:

Tincture of iodine, 1 oz.
Glycerine, 2 oz.

This procedure may be repeated once daily for three or four days, when the danger from this source of infection may be considered as having passed.

It is perhaps needless to say that when these measures of prevention are being carried out, ordinary sanitation must not be neglected. Undue contact of the pregnant animals with material or persons coming from infected premises or stables must be avoided. Special care should be taken in order to destroy the evacuations of sick calves and when those die the carcasses are to be disposed of by burning as being the best means of destroying infection. Stables should be well drained and no large amounts of stable manure should be allowed to accumulate. In selecting a place for corrals, pens, etc., the question of drainage must not be lost sight of, as it is far from being conducive to health to have cow lots filled knee deep with slush, mud and manure. In dealing with any infectious disease the saying that cleanliness is next to godliness should be foremost in our minds.

NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

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Bulletin No. 55.

FLAX AND FLAX SEED SELECTION.

By H. L. BOLLEY.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

Fargo, North Dakota, U. S. A.,
March, 1903.

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FLAX AND FLAXSEED SELECTION.

BY H. L. BOLLEY.†

If one wishes to succeed in flax culture, he must look well to the quality of the seed which he places in the soil.

Flax is not more exacting in its demands upon soil fertility than other farm crops, but is attacked by a number of destructive fungus diseases, which may persist in the soil when once implanted there. This is the explanation of the occurrence of flax-sick soil.

Though North Dakota now annually produces flaxseed in quantity equal to or exceeding the total yield of all other states, our farmers are not particularly happy over the result. As indicated in our Bulletin No. 50*, the crop has everywhere had its drawbacks, and there are troubles brewing for it here. The farmers are rapidly learning that, under present methods of extensive cropping the good fortune of such abundant yields must be looked upon as but temporary, the result of virgin soil. It is the experience of all, that only a few crops can be taken from the same land before it ceases to give the expected bounteous harvest.

The desirability of keeping this important crop as a permanent element of the agriculture of our state and nation can hardly be questioned by anyone interested in the development of permanent industries. An independent country should produce its food and clothing. To do this it ought to use its most available resources. We produce much cotton and a large supply of wool. We could, it seems, produce an immence amount of flax fiber, at least ought to do so. Would there be any use for it? If our general import list of raw materials means anything the answer is evident. For the year 1901, the United States imported* animal fibers to a value of $42,581,246, miscellaneous vegetable fibers to a value of $29,720,334. Of these vegetable fibers, $22,932,506 worth consisted of flax, hemp, jute, sisal, and other coarse fibers. From this last amount, $1,880,717 is the sum paid for flax fiber, of which but 6,878 tons were brought in, showing an approximate average value of $275 per ton. It would seem that these figures ought to appeal to the American farmer, who can now call to his aid the most improved types of farm machinery which the agricultural world has ever known. However, though flax fiber has many advantages of quality over its competitors for the market, and linen goods of all types are always in demand, as a nation, we still buy foreign linens in quantity; and practically all raw materials for the manufacture of thread, rope, twine, cordage, bagging and coarse warped stuffs are a matter of import.

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*Flax Wilt and Flax-sick Soil, December, 1901.

†In all the laboratory work preparatory to the construction of this bulletin, Mr. Thomas Manns has, as Fellowship Assistant, rendered much aid.

In consideration of these conditions, it may be well to look for the reasons, especially as, during the past 35 years, the flax fiber production of the states has fallen off so as to amount to almost nothing.

FLAX CULTURE IN THE UNITED STATES: The original settlers of America were not strangers to the methods of flax growing or of producing home prepared fiber and homespun linen goods. They did as the Russians do today. They produced fiber for their own clothing and had enough to sell. As early as the thirties of the last century, the production of flax fiber had reached the 1,000,000 pound mark, and, in the year 1869, over 13,000 tons of the fiber were produced, chiefly by the states east of the Mississippi. Since that date, there has been a constant decline in fiber production and an increase in the production of flaxseed. The following table* is an interesting showing in regard to this point:

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*See Yearbook of the Department of Agriculture, 1901, page 795.

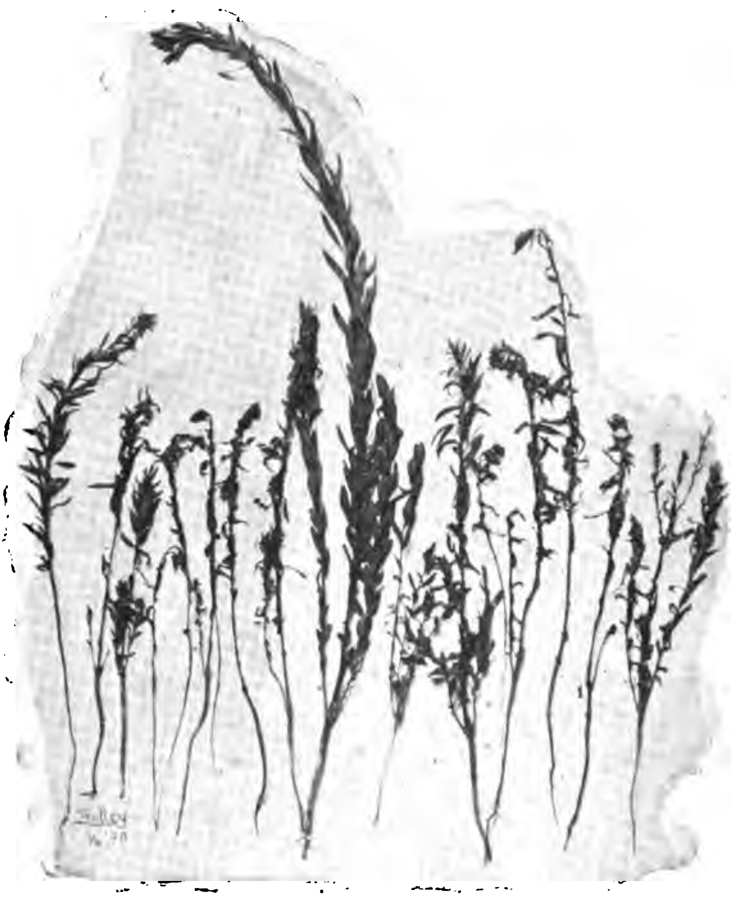
*See Dodge, Report No. 9, U. S. Department of Agriculture, in "A Descriptive Catalogue of the Useful Fiber Plants of the World."

FLAX PRODUCTIONS IN THE UNITED STATES.

Year.	Bushels of Seed.	Pounds of Fiber.
1849	562,312	7,709,676
1859	566,867	4,720,146
1869	1,730,444	27,133,034
1879	7,170,951	1,565,546
1889	10,250,410	241,389

The product of fiber in 1889 was, excepting a small amount produced in the state of Virginia and Kentucky, merely coarse tow. The increased seed production is also seen to be but a natural consequence of the "flaxing out" of the virgin prairies of the western and northwestern states. Thus, while the yield of flaxseed in North Dakota, South Dakota, and Minnesota, in 1899, was 16,114,617 bu., or 12,249,742 bu. more than all states in the union besides, and the totals for these three states are yet on the increase, this fact is to be accounted for by the great increase in the acreage of new prairie lands placed under flax cropping, and not to any improved methods of farming. Some new and better methods must soon be found, and a change of purpose in the growing of the crop occur, or the flax industry of the country, it would seem is surely doomed. Flax as a first crop from new soil is now at its last stand. The travel of the crop from east to west has been so rapid in its change of location that no permanent fiber manufactory could possibly develop. Even the machinery of tow mills has been worn out by constant carting across country to keep up with this nomad crop. As now cultivated, it continually demands new soil areas. Thus the crop has finally come to North Dakota, not as a permanent one, unless a change is made at once in the methods of farming it.

THE CROP IN OTHER COUNTRIES: The native country of flax was probably south-central or western Asia. There are numerous native or wild species of rather world-wide distribution. An examination of the specimens stored in the national herbarium at Washington showed over seventy distinct species, each having a wide range of distribution. Of these, twenty-two were American and the others were of Asiatic, African, and European origin. Sufficient study was given to this collection to assure me that a study of the wild flax plants of the world in garden culture might yield scientific facts of much practical worth. The cultivated form of the plant, *Linum usitatissimum,* is grown throughout the world in temperate regions; and allows a wide range as to soil and climatic variation. When this species came under domestication, is unknown. The time certainly antedates all forms



CUT 2.

Photograph showing the effects of the wilt disease upon flax plants of various ages.

of historical record. It is certain that the linen industry of Egypt flourished some thousands of years before the Christian era. At the present time, the principal fiber countries are Russia, Austria, Italy, Belgium and Ireland, while the chief seed producers are Russia, United States, British India, Argentina, S. A., and Austria-Hungary, named in order of importance in production. Russia produces much more fiber than all the other countries combined, but in seed production is closely followed by the United States, and by British India. The following table* showing the yield of fiber and seed in 1900 is of interest in this connection:

SUMMARY OF FLAX PRODUCTION, SEED AND FIBER, IN 1900.

America	29,184,000 bu.
Europe	23,272,500 bu.
British India	12,000,000 bu.
Algeria	10,000 bu.

Of the 29,184,000 bushels produced in America, fully 13,000,000 bushels grew in the state of North Dakota, and the crop for the season of 1902 was easily 16,000,000 bushels. The position which our state holds in seed production is thus seen to excel that of any equal area in the world.

Through the investigation of the literature of flax culture, and by an extensive correspondence with flax experts, I learn that flax culture has always been characterized by the same failings and difficulties. The two great difficulties relate, first to the cost of labor demanded to save the crop properly, especially for fiber production, and second to the more serious fact that the crop has always been found to unfit the soil on which it is grown for future growths of flax in any thing like close succession. This latter condition has tended to prevent the crop from becoming a permanent one, except in certain districts. Its lack of permanence in a given farming region, of course militates against the establishment of permanent manufacturing industries. However, the crop is an old one in many Russian provinces, in northern France,, Belgium, Holland and in Ireland, and forms an important element in the agriculture and manufacturies of these peoples. From Dr. Franz Schindler,** I learn that the flax fiber industry of Russia was an important one as early as the 15th and 16th centuries. As early as the year 1790, the exportation of fiber had reached 1,115,000 Pud, (4,027,380 lbs.). In 1840, the export of flax products from that country took first place in value, representing

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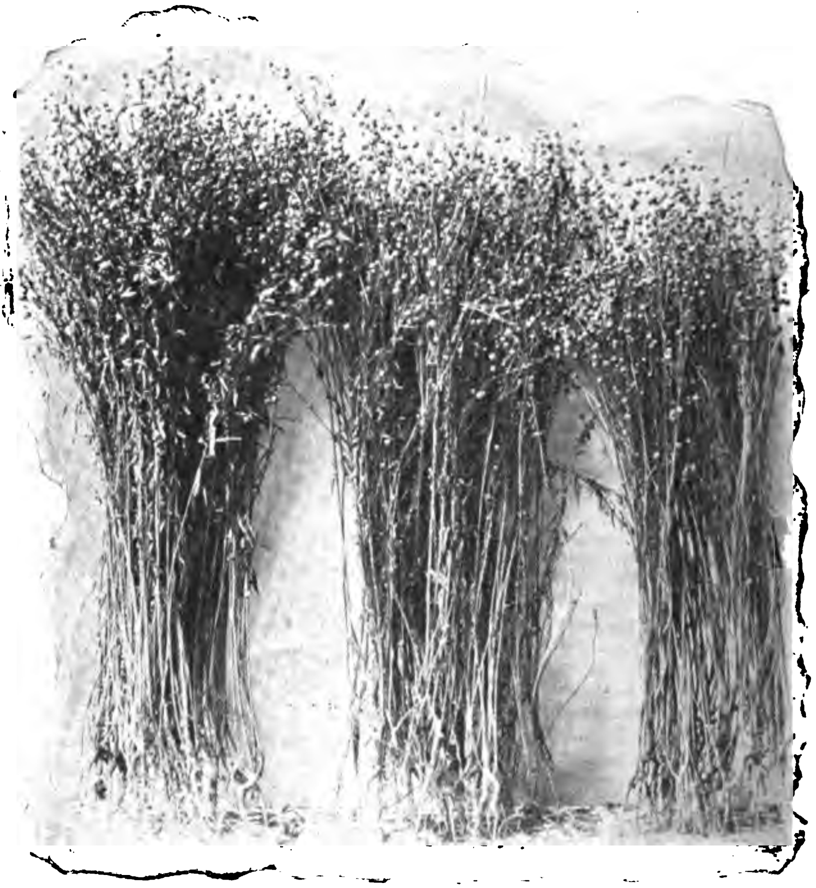
*See Yearbook of the Department of Agriculture, 1901, page 761.

**Die Flachsbau und Flachshandels-Verhaltnisse in Russland, p. 1.



CUT 3.

A photograph illustrating the effectiveness of a proper treatment of flax seed for the prevention of flax wilt. Bundle No. 1 shows the growth from a formaldehyde treatment; bundle No. 2. from untreated seed; bundle No. 3, from untreated seed planted with an extra infection of the spores of the flax wilt fungus. Each bundle represents the entire crop from an equal area of ground.

21 per cent of all their exports. During the period from 1889-1898, the annual export* of Russian flax products was 721,000 tons at a value of, approximately, $50,000,000. This, however, does not well show the value of this crop to the Russian peasantry; for they, in large part, produce their own clothing and there is besides a large home consumption of the different flax products. The crop has also been a permanent one in parts of Austria, in northern France, and in the Netherlands; and these countries yet gain a large revenue from its production.

EUROPEAN AND AMERICAN FLAX GROWING CONDITIONS CONTRASTED. A study of the general distribution of the crop shows that it is able to withstand a wide range of climate and soil variation. It is grown successfully, either for fiber or seed, from Algeria on the south to Archangel on the north. The best grades of flax for fiber are produced in regions of fertile soil and in districts of even, moist, rather low temperature, such as is found in the Low Countries, and the Baltic provinces of Russia; while the great seed producing areas have drier, less fertile soils and drier, more rigorous climatic features.

A study of the temperature and moisture records shows that there is as wide a range of variation in the different Russian flax producing provinces as that found upon our Northwest plains. Indeed, there are many similarities of conditions. Thus the Russian flax areas all lie well within the mean temperature lines which enclose Manitoba, North Dakota, Minnesota, Iowa, Wisconsin, and parts of Michigan. For example, the same lines of temperature *(isotherms)* July 60° and January 0° pass through Archangel, Viatka and Winnipeg; and the great flax producing areas of each country lie just south of this line.. Again, the isotherms of July 80° passes through Pierre, S. D., Dubuque, Iowa, and slightly south of Odessa. A consideration of the moisture conditions of the areas included does not show an unfavorable comparison; and the soils of North Dakota are without doubt sufficiently strong and of a proper type. The Russians raise heavy seed crops upon their dry, windy plains and make a marked success of producing both fiber and seed in the central provinces, under soil and climatic conditions which resemble quite closely those of the Red River Valley. Two features of the Russian culture, however, are very apparent, (1) More attention is given to the variety and quality

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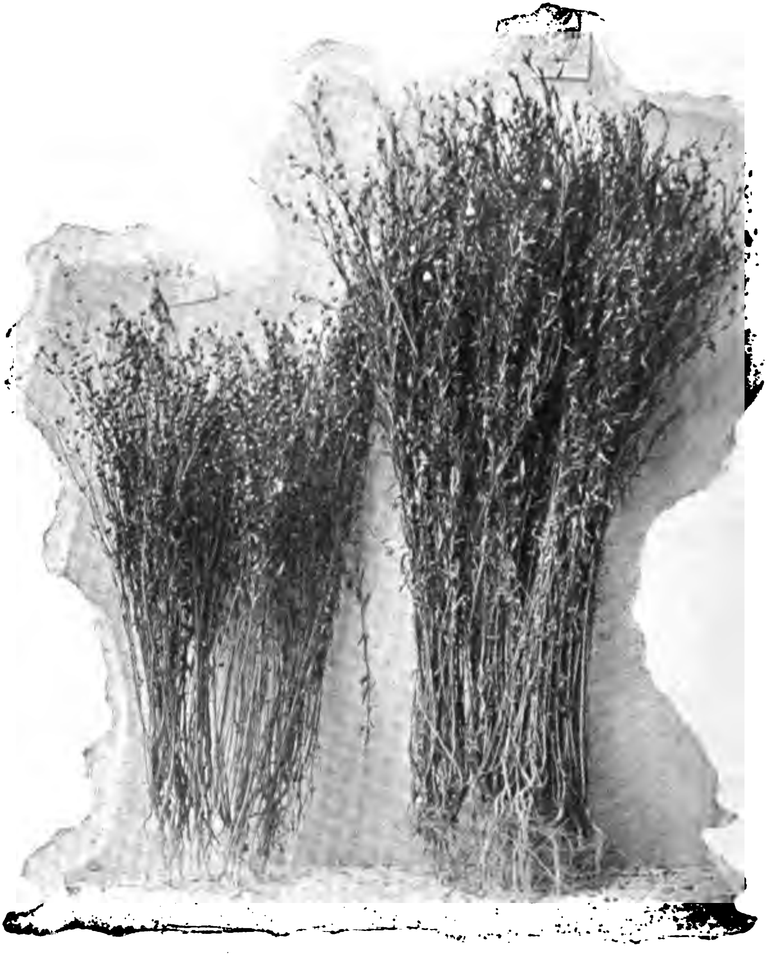
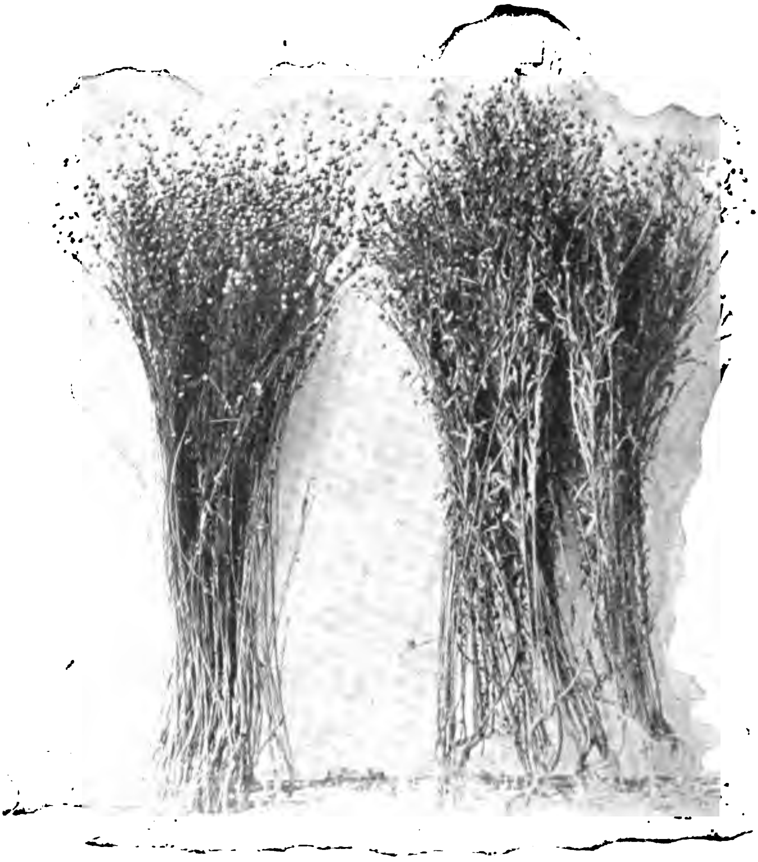
*Catalogue des Collections du Department de L'Agriculture a L'Exposition Universelle de Paris en 1900, p. 50, by Prince V. Massalski, chief of the Department of Agriculture, St. Petersburg.



CUT 4.

Photograph of *short* and *long* seed flax. Each bundle was grown from the seed of one plant which was selected from a field of seed flax in the summer of 1899. They grew side by side and were planted and cared for alike. NOTE: It may be said that this flax and that shown in each of Cuts 5, 6, and 7 was grown during the very dry season of 1900, and that, in part, accounts for the short straw. However, by sample in Cut 6 it is seen that we even then grew straw 36 inches long.

of seed used, crop rotation, etc., and (2) Flax farming and the production of fiber are much more closely associated than in this country, the peasants there, each in a small way, producing both seed and fiber. It seems apparent that the difficulties affecting the success of the crop and industry in this country are, in general, not those arising from poor soil and climatic conditions, but are rather to be referred to methods practiced in the culture and in the handling of the crop, which American machinery and intelligent labor ought readily to overcome. Most of the trouble due to improper methods of culture will disappear when our farmers recognize the importance of growing their own flax seed from pure strains or varieties, and when they have in view a definite purpose with regard to the quality of seed and type of straw to be grown. A very great gain will also be made when our people have reached such a study of the fiber side of the question that this most valuable part of the crop may be saved. Because of the cost of labor, we cannot hope to compete with the hand labor of European peasants. To succeed in this fiber production we shall have to develop types of farm machinery which may not only take the place of hand labor but excel it in quality. A machine for pulling flax seems possible of construction and would do much toward building up our growing fiber industry. The rational flax crop for North Dakota is one grown both for fiber and for seed production; but to succeed, the farmers will have to select their seed and keep it pure when once it is obtained. The growth of the present fiber and tow industry, if properly fostered, ought to grow naturally into a permanent fiber industry, in which much finer grades of fiber may be produced. It cannot, however, last, in any particular community, unless the farmers can keep up the supply of straw. If it is to improve, the quality of straw produced by the farmer must be improved. This can only be accomplished by a rigid determination to improve present methods of cropping, especially the principles of growing, selecting, curing and saving flax for seed.



CUT 5.

Example of first year's selection for comparison of *earliness* and *lateness*. The selections were made from the same field as in case of the seed for the growth shown in Cut 4. There was two weeks difference in the date of maturing the seed in these two selections.

A STATEMENT OF THE TROUBLES CONNECTED WITH THE GROWTH OF FLAX IN AMERICA: The difficulties affecting the growth of the flax industry with us may be summarized about as follows: (1) The cost of labor and the absence of machinery to properly make use of the straw for the development of the fiber side of the industry results in a great loss to the farmer and all others concerned.

(2) Carelessness as to the quality and variety of seed used for sowing results in poor crops, poor quality, and diseased soil.

(3) Lack of knowledge as to methods of culture often results in much loss in crop value, if not also in injury to the soil.

(4) Diseases which attack the crops and a lack of knowledge of their effects result in poor crops and final sterility of the soil for flax.

In this bulletin I propose to consider only points 2, 3, and 4, and hope to point out methods of procedure which will lead to profitable results.

DAKOTA CONDITIONS OF FLAX CROPPING: First let us consider the methods of growing the crop in this state.

North Dakota is now a greater producer of flax seed than any other equal area. In 1902, it is conservatively estimated that the yield of matured flax was between 13,000,000 and 16,000,000 of bushels. Fully one-third of the area under crop was subjected to autumn frosts. It is estimated that had the state escaped this one early frost the yield of seed would have approximated 25,000,000 of bushels. It is also a well known fact that the general average yield per acre for the state was also much reduced, because of weak types of seed in the spring, deep planting and poor drainage, etc. There were other large areas on which the crop was almost or even a total loss because of the occurrence of the wilt disease (*flax-sick soil*). We have by experiments and observations learned that such soils are not really exhausted for flax and have reasons to believe that proper types of seed would overcome the troubles and allay or remove all prejudice against flax as a crop. (See our bulletin No. 50 and other published records to show that the trouble is not soil exhaustion.)

The great yield in the state is, as elsewhere stated, due to the vast areas of new lands which are now being placed under flax cropping. Unfortunately this cannot last under the present regime of carelessness and wholesale seeding. The older flax areas, especially in Minnesota and the Red River Valley region of North Dakota, are rapidly losing their capabilities for producing a paying crop. Cropping under the present methods and with the present types of seed, western prairie soils lose their capabilities to produce a crop in from one to four or five years, whether the seed is sown in ordinary rotation with wheat crops or in close succession, flax after flax. Our proofs are such as to convince us that the entire reason for this condition is to be found in the poor, diseased types of flax seed which is generally used.

In order that any farm crop may be grown successfully, and be developed in its qualities by the farmers of a particular region, there should be one or more standard varieties or strains of such seed in general use. These types of seed should be sufficiently well marked in character that the ordinary farmer may easily recognize them. (As witness, Haynes' Blue Stem Wheat, White Russian oat, Minnesota King corn, Early Ohio potato, etc.). No such recognized strains of seed flax exist in the entire flax growing area of the United States. It is all mixed in type, and, for such reason the crop suffers its greatest drawbacks, among which may be mentioned uneven ripening, frosting, both spring and autumn, and diseases of various types, including that particular type of disease which is the direct cause of flax-sick soil. The farmer cannot hope to mature an even, perfect quality of seed from a mixed lot of varieties and strains. By the use of such seed, the way is open for a perpetuation of all of the troubles to which the crop is heir.

Such pure varieties of seed flax cannot be obtained or purchased upon the open market. All such market seed is subject to mixing at the central shipping points, as for example Buenos Ayres, Riga, Reval, Rotterdam and Minneapolis. Thus, for example, the noted "Riga" flax does not indicate a variety or strain, but simply that the sample so marked is from the export town of Riga, Russia, where the flax from many Russian provinces and districts is placed upon the general export market. Speaking upon this point, Professor Franz Schindler* says: "In the seed sorting at Riga, unfortunately, insufficient care is taken with reference to the origin especially, seed from the different provinces are often mixed with one another." From Professor Jaczewski of the Botanical Institute in St. Petersburg, I learn that nearly one hundred varieties of flax are recognized in Russia.

They Use Mixed Seed and of Poor Quality: As our first samples of seed came from Russian ports and as farmers have never made any definite effort to breed or save pure varieties, it is easy to surmise that the entire crop of seed in this state is a mixed lot. This proves to be the case upon close examination.

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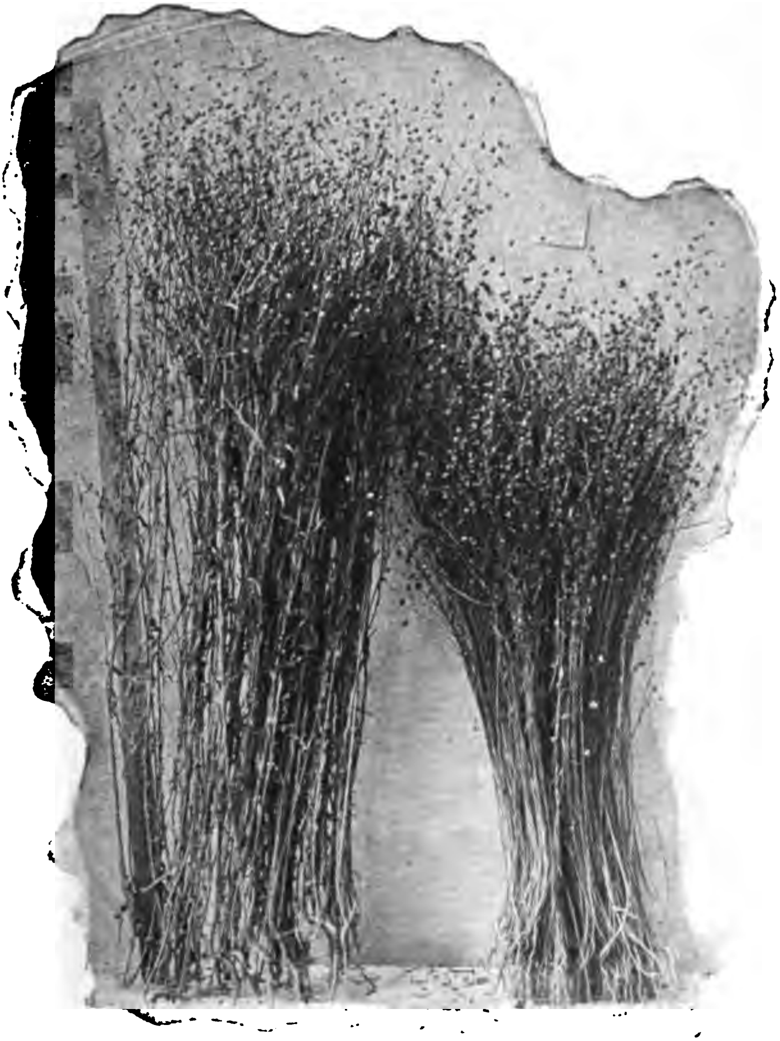
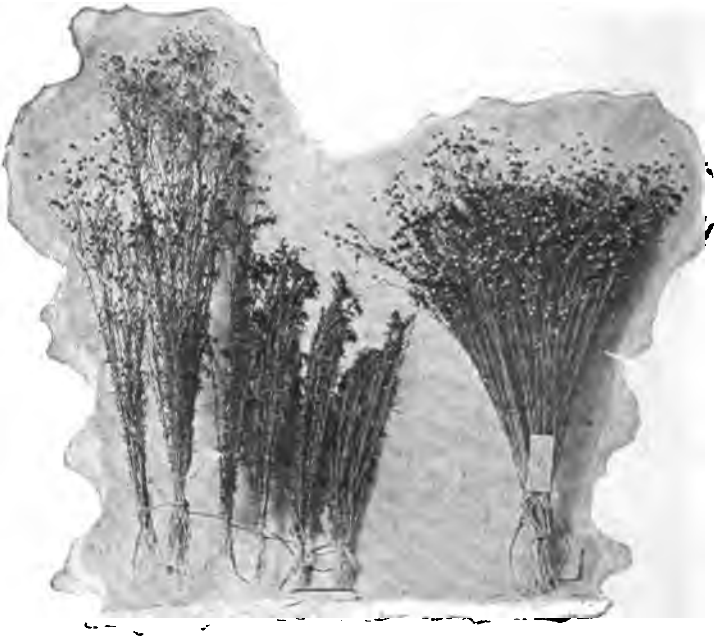
*Flachsbau-und Flachshandels-Verhaltnisse in Russland, p. 46.



CUT 6.

Photograph showing the possibility of improving our strains of *fiber* flax by selection. The parent plants for these two bundles were selected from the same field of fiber flax, and were planted and cared for alike during the season of 1900.

Many farmers are trying to raise an even maturing crop from a mixture of varieties and strains. Even fiber varieties are present in almost all of our Dakota samples of "common seed." If all our different varieties and strains of wheat were dumped together into the elevators of this country, and the farmers used seed from such a mixture, every one knows, at once, what would be the result upon the general crop. It is apparent that there would



CUT 7.

The bundles of flax shown in this cut were all grown from the same sample of seed flax which was hand picked to an evenness of quality. The seed for each was sowed upon the same even bed of soil, on the same day, but at different DEPTHS. The crop was grown during the dry season of 1900, and illustrates well the evil effects both of deep planting and of planting on an irregular seed bed which might allow the seeds to be buried at different depths. All were pulled on the same date. The flax shown in the large, mature bundle grew from seed which was planted ¼ in. deep. The bundles in the series grew from plantings at depths varying from 4 inches on the right to only ½ inch on the left.

be uneven ripening of the crop with all its attendant evils. This is just the case with the present flax crop of the country. Very few farmers take the trouble to grade the seed to an even standard of quality and size before seeding as they do in the case of wheat and other grains. Indeed, if I may judge from the samples sent to the station for examination, many believe that any dark-colored shriveled stuff will do for seed, if only it is but strong enough to sprout. This is a great error and not only results in poor, uneven crops but is rapidly ruining the soils of the state for flax growing; for most such dark-colored, shriveled, scaly seeds bear the germs which cause flax-sick soil.

Poor Methods of Culture: Poor methods of culture with regard to preparation and care of the soil and seeding are responsible for much loss in crop value and serve, in part, to perpetuate the poor qualities of seed in use by the farmers. In this connection, we may name: (1) late seeding which allows the crop to be frosted before mature; (2) sowing upon a rough, uneven seed bed, resulting in uneven germination of the seeds, hence an uneven maturing crop; (3) deep planting, resulting in great weakening of the aftergrowth from all seeds, and many young plants either die before reaching the surface, or are so much weakened that they are often green when the rest of the crop should be cut. It is impossible to save such a crop without either loss by shelling or loss in grade by the presence of immature, soft seeds.

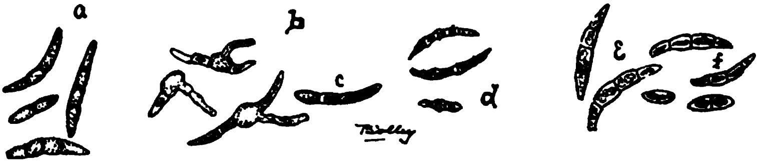
CUT 8.

Sketches showing: 1, scaly flaxseed, and 2, smooth, plump flaxseed. Farmers should screen out all scaly, immature seeds. They harbor the spores of flax wilt.

Lack of Proper Crop Rotation: The worst evils arise largely because of the persistent disregard of the most elementary principles of crop rotation. Men who know that no soil can continue to produce the same crop of plants in close succession, losing their head in hope of temporary riches, persist in sowing flax year after year upon the same land. The result is flax-sick soil, and it comes the sooner because they pay but little attention whether sound or imperfect, scaly, diseased seed is used. Real estate companies and speculators rejoice in this wholesale method of destroying the soils of the state, while they wait a year or so for a rise in the price of the new lands which they hold. The lands thus cropped are not only filled with disease due to the poor seed used, but become sources of soil infection for entire neighborhoods. Flax should not be seeded upon the same land more often than five or six years; for if by chance a few points of soil infection occur, the sick areas enlarge from year to year by feeding upon the constantly increasing masses of flax rubbish in the ground. Every farmer in the state knows a neighbor or so who is thus careless about the quality of seed used. Would it not be a matter of policy and self preservation to try to educate such men to do differently.

DISEASES OF FLAX AND FLAX-SICK SOIL: Since Bulletin No. 50 on Flax Wilt and Flax-sick Soil was written, December, 1901, we have learned many new points with regard to the general trouble. The chief of which is that besides the regular fungus, (*Fusarium lini*), which was demonstrated to be the cause of the characteristic wilt disease, there are other species of fungi which may kill young flax plants and persist in the soil so as to take part in the production of the conditions of the soil which make it sterile for the growth of flax.

Detection of the Presence of the Disease Producing Fungi in the Seed and Soil: As the fungi which occasion this sterility of soil are microscopic in size and form, it is of the greatest importance to be able to detect their presence in the soil or in seed grain. Considerable effort has been made to accomplish this result. It has been found that by means of the ordinary physician's centrifuge, one can readily detect the spores in the



CUT 9.

Figure showing: *a*, Normal untreated spores of *Fusarium lini*; *b* and *c*, the same after a weak treatment with formaldehyde—some cells are yet able to germinate; *d*, spores which were killed by formaldehyde; *e* and *f* show the effects of different strengths of corrosive sublimate solution. Highly magnified.

seed. A large number of seed samples from all parts of the state, and from several counties in Minnesota, have been examined. It is found that the disease is very generally distributed, fully eighty per cent of the number of samples examined were heavily infected. This teaches that farmers ought not to rely upon unknown flax for seed purposes. One ought to grow his own seed. See Bulletin No. 50 upon this point. The spores of the wilt organism have also been detected in flax seed from the following foreign countries: Argentine Republic, Japan, Austria, Holland, Russia and Belgium.

In conducting this work, we have also found that there is a second species of Fusarium of much larger form than the species *lini,* which possesses the same flax destroying ability. There is also a species of *Colletotrichium,* which is very destructive to young flax plants; and a species of the Genus *Alternaria* is very destructive to young plants in damp soil. It is also probably the direct cause of a peculiar boll stem disease which kills the young bolls or the fine branches to which the bolls are attached just when the seeds should be forming, giving the appearance of ripening prematurely. During the season of 1902 this last disease very greatly reduced the crop in almost all parts of the state. By methods of soil analysis it has been found that all of these different fungi live in the flax-sick soil from year to year. The study of their natures, characteristics and life habits in the soil, in manures, etc., forms a very important present line of investigation.

THE WILT DISEASE PROPER: The following are some of the chief points concerning the wilt disease:

1. There is a diseased condition of flax soils which has long been known to farmers in flax producing regions as flax-sick soil.
2. If flax is sowed rather continuously for a number of years upon the same soil, this disease tends to thoroughly infect the soil so that flax growing becomes no longer profitable.
3. The disease may be spread by way of the seed flax.
4. The plants attacked die at all ages as if for want of water; hence I have called the trouble the flax wilt disease.
5. The direct cause is a minute fungus parasite which grows on the inside of the flax plant, starting either from the seed, or by attacking the roots of older plants, if the soil has previously been infested.
6. There are many ways in which the infection might reach new fields, but the chief one is by way of the seed.
7. The spores of the parasite get into the seed flax at thresh-

ing time, rattling off from the sides of the flax straws which have been attacked by the parasite.

8. When such infected flax seed is sown, the spores of the fungus germinate and at once attack the young plants. Those attacked early die at once and there may be no stand even from good seed if the spores of the parasite are abundant. When once in the ground the fungus spreads rapidly, attacking new plants throughout the season. It can live from year to year upon the humus of the soil, hence the soil is ruined for flax.

9. All other farm crops do well upon the flax-sick soil. It has not lost fertility for flax, as is proved by experiments which destroy the spores without injuring the soil.* If soil is once infected, these last facts teach that the farmer should have recourse to the growth of other crops than flax until the land is again free of the disease. This is exactly what has always been done in Russia and other noted flax countries, though, heretofore, it was never known why this rotation was so necessary to flax.

10. The fungus belongs to a genus of plants which botanists have called Fusarium. As this is a new species, I have called it Fusarium lini.**

11. Much of the soil of this state has not yet been infected, but practically all samples of seed flax yet examined show the presence of the Fusarium spores. It is probable that no sample of flax seed is entirely free from infection by this particular fungus parasite. Our latest studies show that one or more other species of this same genus are also active.

12. One of the worst features of the wilt disease is that some plants which are attacked late in the year are able to partly mature seed. Many of such seeds are found to be internally diseased; that is, the parasite has grown from the mother plant up into the embryo within the seed coats. Such seeds cannot be treated so as to prevent soil infection without killing the seeds. Each internally infected seed invariably produced a wilted plant some time during the growing season, and each wilted plant starts a new area of soil infection. We have worked with samples of seed flax which contained as high as 25 to 30 per cent of such internally attacked seeds. If a sample of flax has been properly ripened and saved dry, one can usually recognize internally diseased seeds. They are often imperfectly developed, may have a dark colored point, or may have a spot or area of improper color

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*See Bulletin No. 50. North Dakota Experiment Station, page 35, Experiment No. 1.

**Same citation, page 38.

showing through the transparent seed coat. In samples of seed from a diseased crop, there will always be found many light weight, dark colored seeds. Often the seed coats are scaly or scurfy because attacked before properly matured. The seed coats of such seeds are usually thoroughly infested with one or more types of disease producing fungi, including the wilt fungus.

13. The resting spores of the wilt producing fungus are developed in the pith or other open tissues of the stem of the flax plant. This kind of spore is very resistant, and being protected by the tissues of the stem is safe from injury in the ordinary methods of seed treatment. Bits of diseased stem, even in treated samples, start points of soil infection. Bits of chaff or the hulls of the flax bolls may do the same thing. (See Bul. 50, p. 37.)

14. Barnyard manure in which disease bearing flax straw or waste has been thrown is probably one of the worst sources of soil infection. We have proved by experiments and by numerous observations that one application of such infected manures may ruin the soil for the growth of flax.

15. The growth of weeds in a flax crop is very favorable to the rapid increase of the disease from year to year. Flax bundles which contain a lot of rough green weeds cannot properly dry out; and we have found that the fungi which produces flax sick soil multiply profusely in such damp straw and even invade the seed coats of mature, though damp seeds. Seed flax which came from even a slightly diseased crop, if stored damp, is found to be very destructive to soil for the same reason.

16. These soil infecting fungi have been found to be cosmopolitan with the growth of flax.

17. We have not been able to associate *Asterocystis radicis*, Wild.* with the production of flax sick soil in the field. This organism is a common, widely distributed one but seems to be harmless under our conditions.

18. Common rust of flax (*Melampsora lini*) causes an early browning or maturing which is often mistaken for wilt, but may be recognized by the yellow or orange spots upon the green leaves and by black spots upon the older parts of nearly mature stems. Rust seems to do but slight injury to a crop which is grown for seed purposes.

19. Besides the resting spores which are on the inside of the flax straws, numerous crescent shaped spores (see cut 9) are found on the outside of the stems. It is these spores which become abundantly dusted over all of the seed at threshing time.

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*Marchal, Recherches Biologiques sur une Chytridinee Parasite du Lin in Bulletin de L'Agriculture, Tome XVI, p. 574, Brussels, 1900.

20. Proper seed treatment insures the killing of all wilt producing spores which are present on the outside of the seeds, or may be intermixed as dust particles.*

THE REMEDY IS PURE, CLEAN, MATURE SEED: It is evident from a consideration of the conditions cited under points 12, 13 and 15 that proper seed selection, seed cleaning, curing and grading are first essentials to the prevention of flax sick soils. Proper selection demands that one should raise his own seed, and that he should save the best possible cleanest, undiseased, weed-free part of the field to thresh for this purpose. Proper curing demands that the seed must be harvested when mature and when dry, threshed when dry, and that it must be kept dry. Proper cleaning insures the removal of dust, dirt, straw, chaff and light weight, imperfect seeds, all of which trash may contain the wilt producing spores. Proper grading leaves only large, plump seeds. If the color of these is seen to be bright, one can rest assured that after using the formaldehyde treatment, there will be a clean, healthy stand of flax when it is sown upon clean undiseased soil. No sample of flax seed should be trusted without treatment. We have been unable to find one which is entirely free from the wilt fungus. Proper seed treatment greatly improves the first growth from the seed. Our experiments teach that a stronger growth occurs from properly treated seed throughout the season.

SEED SELECTION: This is the line of work from which I have much hope both from efforts to be continued at the Experiment Station and from the work of the farmers themselves.

Against the common belief that there are but one or two varieties of flax, my experiments, correspondence and samples of seed on hand, teach that there are several of very definite character. The general flax seed products commonly spoken of as "common fiber flax" and " common seed flax," by our tests, appear to be only general mixtures of strains and perhaps varieties. We have proved that in these mixtures there are early ripening types, frost resisting types, fiber strains, seed types, and finally wilt resisting types. As to the matter of resistance to frost or to wilt, the tests tend to show that it is probable that some samples of common flax are more or less resistant in character, acording to the purity of the sample.

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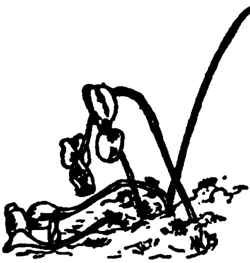
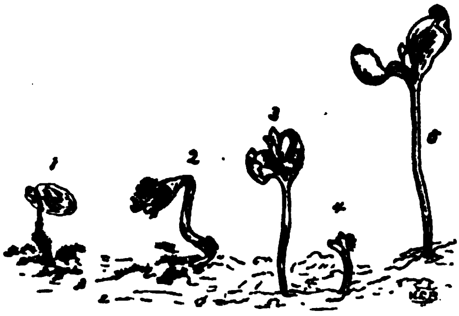
*For many other general notes and observations upon the characteristics of the disease; and for a description of our experiments with different substances for seed disinfection, methods of disinfecting by vapor, etc. consult the Annual Report of the North Dakota Experiment Station for 1902.

This all teaches that there is hope of obtaining flax seed of the type desired, as has been done in the case of other farm crops, and that it is not illusionary to hope to find strains which will produce fine qualities of seed and also strains which will produce fine qualities of fiber under our soil and climatic conditions. One would hardly select the climatic and soil conditions of Dakota for the production of typical fiber flax, yet our experiments at Fargo, and those of Prof. Hays at St. Anthony show that very fine fiber plants can be grown in these climates, to a length and a fineness equal to the best plants produced in the regular fiber producing countries. In 1899 I selected some individual plants from a rather short appearing crop of fiber flax. From the seed which descended from one of these, the farm department grew plants varying in length from forty to fifty-seven inches. This work tends to show that the matter of obtaining fiber types and seed suited to our conditions is only one of breeding strains which are suited to such climatic and soil conditions, In general, our experiments tend to show that these select plants which we have worked with are not simply sports or accidents, but are rather to be looked upon as representatives of real strains or types which are mixed in the samples of "common" seed upon which we have worked. (See results upon early and late ripening, selections for length, strength, etc., as shown in the different photographs taken





CUT 10.

Fig. 1.

Fig. 2.

Fig. 1.—Sketch showing a clump of young flax plants which have wilted, due to early attacks of the wilt fungus from flax sick soil. Original.

Fig. 2.—Figures showing various grades of diseased growth from immature scaly flaxseed. All are moreor less attacked by wilt fungus.

from plants of the first year's growth from our individual selects, season of 1900.)

The details of the work upon the selections cannot be given in full here, but it may be said that the seeds of each pair of parent plants selected for comparison were hand planted, side by side, at an equal depth, under equal conditions, on the same date. The seed from a part of the best fiber plants was turned over to the farm department and the continued selections, during 1901, and 1902, show by the improved products that the flax plant is easily amenable to improvement, year by year, through methods of selection.

IMMUNITY EXPERIMENTS: Director L. Broekema of the Agricultural School of Holland has had flax sick soil under consideration in his own gardens for many years, extending back of 1893, when he reported upon the disease at some length.* He described the disease in all its various forms very accurately and made some very interesting observations upon the fact that certain plants in common seed varieties of sowing flax seemed to possess resistant capabilities with reference to this soil trouble which he characterizes as "Vlasbrand."

As a knowledge of Dr. Broekema's experiments did not come to us until December of 1901, our work of selection along this line had already been outlined and well started. In 1899 we selected from the field plants for earliness, lateness, strength of stem, length of stem, evenness of ripening, rust resistance, freedom from wilt appearance, shortness of stem, etc. Each of these individual plants was threshed separately and the seeds sowed in drills side by side on the same date and under the same conditions of planting. Such marked results were gained in these selections that we at once became aware not only of the fact that flax as a species or variety is exceedingly liable to variation, but gained definite information pointing to the conclusions that the progeny from different individuals show marked variation in ability to resist the attacks of the two diseases known respectively as rust and wilt. These diseases, however, are very different, and plants which seem more or less resistant to rust succumb to the wilt. In 1901 a piece of thoroughly flax sick soil was seeded to flax, using three different samples of seed. The results were discouraging. The young plants died off so thoroughly that, owing to lack of labor at the time, the beds were allowed to grow up to weeds, with the result that no seed was saved; but observations taught that this neglect was perhaps a costly error.

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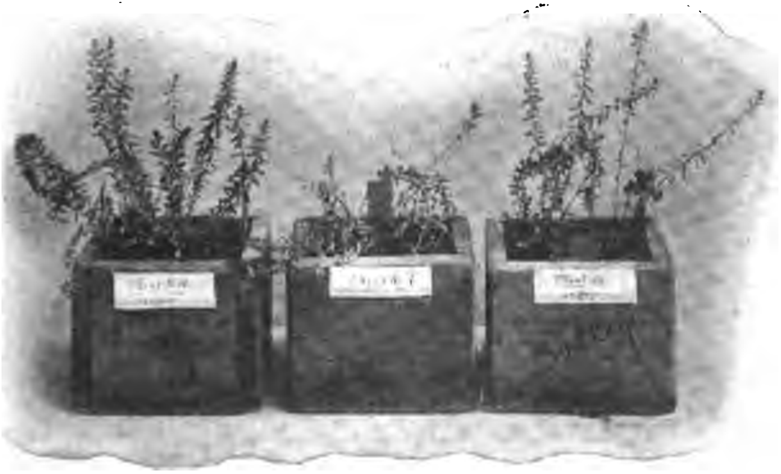
*See "Landbouwkundig Tijdschrift, 1893, Bl. 59 en 105."

In 1902, after sowing a mixed lot of flax seed, which we procured by sending for samples of seed to a great number of farmers in various parts of the northwest, upon a piece of flax-sick soil, we found that a small percentage of plants were resistant to the disease and were able to mature seed, some being slightly blighted by the disease, but many apparently living without the slightest injury. These plants were pulled and saved for a test upon this question of immunity. A part of the seeds from twenty of these plants have been given greenhouse culture in competition with eight samples of common seed flax selected from various portions of the states of Minnesota and North Dakota. These checks were selected because representing apparently variable samples; the seed from these was hand picked and of the best quality in each sample. These checks were either seeded in the same box with the select seeds or in similar boxes of flax-sick soil on the same day and received like treatment. All seeds were planted upon date of December 4th.

The following tables will give an idea of the conclusions which should be drawn from the work:



CUT 11.

Photo showing experiment with immune seed in flax-sick soil. The plants were about sixty days old from the seed. The plants in the right and left boxes grew from seeds of individual plants which grew the year before on sick soil, and were selected for test because they then showed powers of resistance to the wilt fungi. The plants in the middle box grew from a sample of "common seed" planted as a check for purposes of comparison. Most of the plants were dead of wilt at the date of photographing. See table p. 194.

RECORD OF IMMUNE SELECTS, COMPARED WITH GROWTHS FROM "COMMON SEED" SAMPLES.

Plant No.	No. of seeds used	Sound plants Dec. 15	Wilted plants Dec. 15	Sound plants Feb. 5	Plants dead Feb. 5
1.	50 plump	50	0	50	0
	25 poor	10	1	9	1
2.	25	17	1	12	6
3.	25	24	0	24	0
4.	20 large	19	0	19	0
	5 weak, dark	1	0	1	0
5.	20 normal	17	0	17	0
	5 dark	0	0	0	0
6.	10	9	1	8	2
7.	5 plump	5	0	5	0
	5 dark	2	0	2	0
8.	20	20	0	20	0
9.	10	10	0	10	0
With check 4.		15	3	1	14
10.	20 normal	20	0	15	5
	20 immature	13	0	13	0
11.	20 normal	19	0	17	2
	20 dark	20	0	18	2
12.	25	25	0	24	1
With check 6.		12	3	0	12
13.	20	20	0	19	1
14.	20 thin	20	4	12	8
15.	15	15	1	15	1
Check 8.	20 best	20	1	1	19
16.	20	16	0	13	3
17.	20	20	0	20	0
In same box with plant 14.					
18.	25	25	0	25	0
19.	20	17	0	17	0
Poor, thin seeds, the mother plant was not mature.					
20.	25	24	0	21	3
Check 1.	50	30	6	10	20
Check 2.	50	35	0	16	19
Check	20 best	17	1	3	14
3.	5 dark	0	0	0	0
Check 5.	40 dark	33	2	6	27
Check 7.	60	44	3	10	34

By a consideration of the data given in the foregoing table, we find that the select seed gave a very much larger production of plants at germination time, that is, less plants died before getting through the earth, and that out of a total number of 468 plants which came up from the select seeds, only 35 died of all causes, previous to the date of Feb. 5th. These plants mostly died of wilt but came from seeds, the mother plants of which it is known were sufficiently diseased to give internally diseased seeds. Of these dead plants from the selects, 5 parent plants furnished 26 of the wilted seedlings.

In the case of the checks, out of a total of 222 seedlings which actually came up, 159 were dead of wilt before the date of Feb. 5. At this date, Feb. 12th, no further plants have died in the select experiments, while quite a large percentage of the plants from common seed were either dead or dying. March 31st, all check plants were dead except two plants in one box; while all immune plants remain strong and are in blossom.

It is an interesting fact that some of the samples of common seed, such as No. 8, one of the finest appearing samples of flax to be had, are apparently wholly unable to resist the flax-sick soil disease, while in the case of some other samples of seed the number of resistant plants remaining to date indicate a considerably larger percentage of resistant seeds in the original sample.

The conclusion to be drawn seems to be in line with that indicated by our other selection experiments, that common seed flax as found upon the market is made up of a mixture of various strains or possibly varieties, and that some of these strains or varieties exhibit a high grade of resistance to the wilt disease, or indeed any other disease which may be associated with flax-sick soil; and, further, that there is much reason for the hope that we may eventually escape the ravages of this soil trouble by the use of immune strains of seed.

WHAT THE FARMER CAN DO: It is evident that this process of selection and breeding from individual plants or strains must be a slow one, and that the average farmer has no time for such effort. That is the duty which falls naturally to Experiment Stations and Seed Farms.*

There are, however, open to the farmer, the processes of general selection, seed cleaning, seed grading and seed disinfection. He can also proceed to follow a common sense process of crop rotation, which is sure to bring paying returns.

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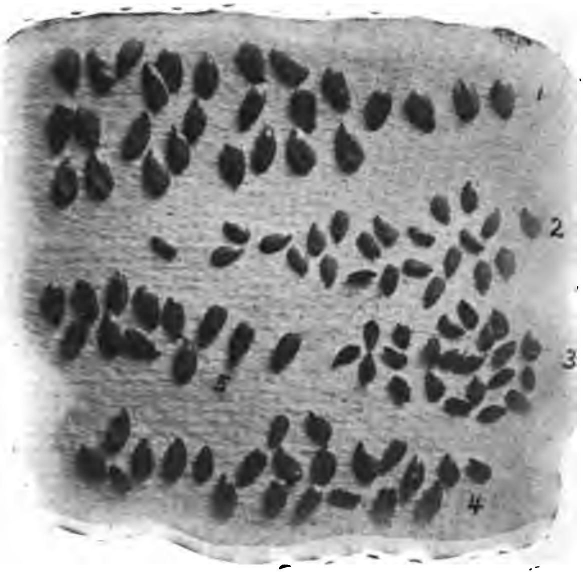
*I think I am safe in asserting that a properly conducted general seed-breeding farm located in the Red River Valley would pay the owner well, and would be a great benefit to the state.

That there is great enough variation in flax samples to allow any one to intelligently make a selection for farm use, I call attention to photograph of seeds shown below, also to the following table which shows the possibility of grading seed flax in a fanning mill.



CUT 12.

This cut shows the *variation* in the size of flaxseeds. Five different samples are shown, all perfect seeds. Let no man tell you that flaxseed cannot be graded to size and weight. See also table.

THE WEIGHT OF FLAX SEEDS.

Sample used	Weight of 10 smallest seeds	Weight of 10 largest seeds
Big Seeded Austrian	.0854 grains	.1270 grains
Yellow Seeded French	.0360 grains	.0480 grains
College Grown Common	.0265 grains	.0530 grains
Langdon Grown Common	.0385 grains	.0630 grains

*NOTE.—All seeds selected were mature and plump. It will thus be seen that aside from the improperly developed and scaly seeds which may be removed, there is plenty of room for the work of grading that may be done by a mill. From the table it is seen that the large seeds, for each sample, average almost or quite twice the weight of the small mature seeds. See also the results of the growth from such seeds contrasted in Cut 13.

RECOMMENDATIONS: (1) Use only plump, bright colored flax for seed.

(2) Treat all seed flax every year. The treatment was found by many farmers to be a great success in 1902.

(3) Before treating clean all seed thoroughly in a fanning mill until all bits of straw and chaff as well as light weight seeds have been removed, or blown out. The treatment recommended will not kill the fungus which is always to be found inside diseased straws and chaff, because it cannot penetrate to it. In a diseased crop, most of the light weight, dark colored and scaly seeds bear the fungus on the inside of the seed-coats. Such seeds must be removed, for the treatment cannot prevent these from infecting the soil.

TREATMENT: Use formaldehyde at the rate of one pound of the standard strength to forty gallons of water. Spread the seed upon a tight floor or upon a canvas and sprinkle or spray on a small amount of the liquid, (a fine spray thrown by a small force pump is best). Shovel, hoe or rake the grain over rapidly. Repeat the spraying, shoveling, hoeing or raking until the surfaces of all the seeds are evenly moist, not wet enough to mat or gum but thoroughly damp. (This can be done without matting, if well hoed or shoveled over). Leave the grain piled for several hours. The dry grains will absorb the excess of moisture without injury or matting, and the spores of the disease will be killed by the fumes. It takes about one-half gallon of water solution to properly wet one bushel of flax seed.

FURTHER PRECAUTIONS: After this care has been taken with the seed, I recommend these further precautions:

Sow all flax on a compact, even seed bed.

Sow flax seed as shallow as possible and yet have it well covered.

Sow smaller areas to flax, and never follow flax by flax until a number of years have intervened.

I recommend the following series of crops until we have learned reasons for a better one:

Flax.
Wheat, oats or barley.
Corn or other cultivated crop or fallow.
Wheat.
Grass.
Grass.
Pasture one or more years, then flax if desired.

Raise your own seed, thresh it in a clean machine from a patch of mature, healthy flax. Keep it dry, for the fungus propagates on damp flax, grows inside the hulls and ruins such seed.

Finally, do not allow any flax straw or waste to get into the manure. It will be impossible to feed flax straw and not have flax-sick land wherever such manure is applied.

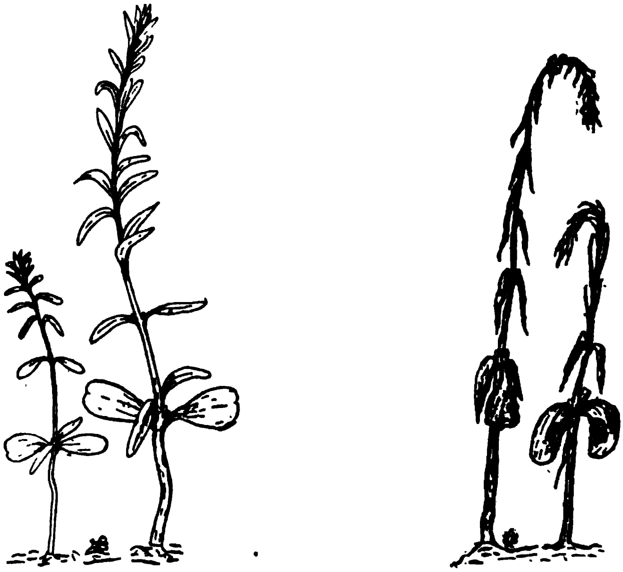


Fig. 1. Fig. 2.

CUT 13.

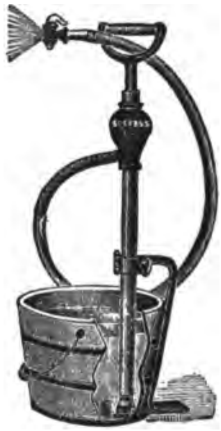
Fig. 1 shows the advantage of removing all small flaxseed, even though sound. The two plants were thirty days old from sound seeds, but the seed from which the large plant grew was twice as heavy as that which produced the small plant. The figure is one-half size.

Fig. 2 shows two wilted plants from internally infected *scaly* seeds. The seed leaves were attacked before the period of germination. See the spots on the right hand plant.

I sincerely hope that the farmers of this state may quickly appreciate the serious nature of this soil disease and begin at once to take all necessary precautions to keep their farms free from the trouble.

HENRY L. BOLLEY,

North Dakota Agricultural College, March 31*st*, 1903.



Cut 14 shows the type of pump one should have to treat grain with by the spraying and shoveling method. The nozzle may be set to throw a spray of any degree of finenes.

NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 56.

NOXIOUS WEEDS AND HOW TO KILL THEM.

By L. R. WALDRON.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
June, 1903.

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NOXIOUS WEEDS AND HOW TO KILL THEM.

BY L. R. WALDRON.

The price of clean land is eternal vigilance.

Methods of weed eradication in North Dakota lie along the lines of improved crop rotation, intensive farming, and pure seed grain.

INTRODUCTION.

The material in this bulletin is merely a collection of well known facts arranged primarily for the benefit of North Dakota farmers. It aims to present in a simple manner, information in regard to which there have been many inquiries. It is believed that here is a field of scientific interest and economic importance, and it is planned in the future to do work along these lines. Various bulletins published in the United States and Canada have aided the author in the publication of this bulletin.

NORTH DAKOTA WEEDS.

The weed question in North Dakota is a serious one, and it is rather an interesting fact that it has heretofore received but little attention. The extensive rather than intensive methods of farming that have been carried on, largely account for this. As the farms become smaller the same ground will receive a greater amount of cultivation, which will render the majority of the weeds less abundant.

What is a weed? Plainly it is a plant out of place and one which persists in remaining so. Thus some of our most valuable forage plants may be considered weeds if they persist in growing where they are not desired. There are a certain number of plants, however, that because of their non-economic value, their aggressiveness, their great seed bearing power and their hardiness become known as "weeds." The number of kinds of weeds is manifestly large, but the number that are a serious menace to farming in one locality do not number more than ten or a dozen. The habits of these vary among themselves, but certain ones present certain similarities of habits. The habits of one mustard may be enough like the habits of another mustard so that the two may be treated as one plant when the farmer desires to learn methods of extermination.

All weeds may be divided into three classes: (a), one-year weeds or annuals; (b), two-year weeds or biennials, and (c), many-year weeds or perennials. (The biennials are of comparatively little importance.) The weeds belonging to class (a), known as annuals, include the most of our common weeds, such as wild buckwheat, yellow mustard, pigeon grass, etc. These plants start from the seed each spring, grow very rapidly and soon put forth flowers and fruit. Most of the annual weeds produce seeds until the fall frosts. The whole plant then dies. The next spring new plants start only from the seed.

Our bad *perennial* or many-year weeds are not so numerous as our annual weeds. The worst perennial weeds in North Dakota are the Canada thistle and the quack grass. Like the annual weeds these weeds start first from the seed, but they do not make much growth the first year. When the fall frosts come these weeds are killed to the ground, but a portion of the plant under ground is not killed, but *lives over winter.* In the spring they start to grow from the underground portion of the plant, and it takes only a few warm days in spring to cover the ground with the green leaves of quack grass or Canada thistle. It is well known that cutting the plant during its growing season seems only to stimulate it to increased growth.

The most important things for the farmer to know about weeds are these: First, learn that weeds are doing the farming industry an immense amount of damage; second, learn to know the weeds themselves, their habits, their names and the appearance of their seed; third, learn the most approved methods of getting rid of them.

WEEDS INJURE YOUR BUSINESS.

Many farmers fail to realize that weeds are doing them much harm or that they are abundant in their fields, when perhaps it is the weeds alone that prevents farming being a profitable business to them. Weeds injure the farmer in three important respects. The presence of weed seed in grain makes the grade lower and injures the grain for milling and often for feeding purposes. Certain weed seed, such as corn cockle and cow cockle are poisonous, and flour made from wheat containing cockle seed is injurious to health. Both kinds of cockle are abundant in North Dakota.

Weeds injure a growing crop by overcrowding and suffocation.

Take wheat, for instance. A certain number of kernels are sown upon an acre. If the wheat is good most of the kernels germinate, and during the cool spring weather the growing wheat plants stool or tiller out, if the conditions are favorable. Wheat will not stool much if it is sown too thickly. When sown thickly there are plenty of wheat plants, but they are still spindling. In such cases we are liable to have a proportionately large amount of straw. If weeds and wheat come up together the weeds prevent the wheat plants from stooling, and so we have spindling wheat plus a useless mass of vegetation,—the weeds, which are robbing the soil of food and moisture. Take wheat again. A healthy wheat plant has rich green leaves. If we keep it away from the light the leaves become yellow and sickly-looking and the wheat plant develops either no head at all, or at best only a small one. Weeds produce the same effect. Examine wheat growing in a yellow mustard, French weed or Canada thistle patch and see if these assertions are not the truth instead of mere theoretical fancies. Unfortuntely we have not the exact knowledge of how much damage weeds do in this way, but I think I am safe in stating that more damage is done than is commonly supposed.

In the third place weeds injure the farmer by robbing the soil of plant food and moisture. If our seasons were long enough it would be possible to grow two crops in succession from the same piece of land. Some farmers have tried to grow wheat and flax together in this state and found neither crop paid. Many farmers evidently think North Dakota soil is rich enough to grow a crop of weeds and wheat or weeds and flax together, and make the wheat or the flax profitable. This is a mistake. It cannot be done. In certain bountiful years it may be possible to grow enough wheat or flax on weedy land to make a small profit, but in the long run it cannot be anything else but a losing business. The weeds knock off the profits. The farmer raises enough wheat or flax to pay his expenses and enough weeds to prevent any profits and there he is, no better off than a year ago. Swift or Armour never made money by selling meat and throwing away the lard or tallow or the so-called "waste" products. In the same way no farmer ever made money by growing corn or wheat and paying no attention to the weeds.

The major portion of the plant food is in the upper six or eight inches of soil. This food is of no value to the growing plant unless it is dissolved in the soil water. If the weeds take up or absorb all of the excess water in which the plant food is found it is plain that the wheat or corn plant will be partially starved.

There may be an abundance of food in the soil, but it is of no value to the plant unless it can be utilized. It cannot be utilized unless it is dissolved in water. The weeds, drawing away moisture continually, prevent the desirable plants from growing as rapidly as they should.

Several hundred pounds of water must be taken up by the roots of a vigorous plant, under ordinary conditions, and evaporated out through the leaves before the plant is enabled to form one pound of dry plant material. The water is needed in the plant to keep it from wilting and to carry on the ordinary life processes. If not enough water is present for this work the plant becomes dwarfed. Many weeds are shallow rooters. They take the major portion of their water from the top ten inches of soil. If there are but two weeds to every square foot of surface, the amount of water taken up by them in the course of a month is really surprising in quantity. *All moisture removed by the weeds thus is a direct loss to the crop.* The weeds take from the soil the moisture that contains plant food that would otherwise be used by the crop. In other words the weeds act in the same manner as a tapeworm does in the alimentary canal of an animal. The weeds use food that would be used to much better advantage were the weeds not present.

The plant foods found in the soil consist of certain salts or minerals such as common table salt, etc. Certain of these salts are abundant enough in the soil at any time to feed a crop for a season. Others, such as saltpeter (nitric acid) are liberated, become available to the plant, or are rendered soluble, only gradually. That is, there may be enough of the saltpeter in the soil to last a crop only a few weeks. As it is used, however, more of this food is rendered soluble so that it can be used by the plant. We have this process going on in the soil during the growing season; the humus or vegetable substance constantly yields a certain quantity of saltpeter, and the growing plants are at the same time using a portion of this. When the growing crop contains weeds there are two classes of plants drawing on this food substance. Nearly all of the weeds begin flowering and ripening seeds long before the wheat or flax or corn begins maturing its seeds. Now a plant that is flowering and ripening seeds draws a greater amount of nutriment or food from the soil, proportionately, than does a plant having only green leaves. The case is somewhat similar to a farmer drawing heavily on his moderate bank account for a pleasure trip just before he needed the money to harvest his crop. The weeds draw on the bank account in the soil for plant food that should be saved for the wheat or other crop.

Perhaps enough has been said to show that weeds are a positive injury to the farmer in many ways. It must always be remembered that they attack the profit end of a crop. It is not difficult to raise enough grain to pay expenses, but every dollar taken in as profit is a matter of increased difficulty. Every factor that decreases the output of a crop, but does not decrease the cost of raising the same, is one that should be eliminated. It is thoroughly believed that the weed question in this state today is such a factor, and any work looking toward the relief of this situation should receive careful attention at the hands of all farmers.

KNOW THE WEEDS.

This is more important than it seems at first sight. Not until a farmer learns something about the weeds on his farm, their names, their life habits, the injury they are doing, will he be interested enough in them to try to eradicate them. The amount of weeds upon many of the Indian farms in this state is notorious, and it is here that we find the knowledge in regard to weeds and consequently the interest taken in their removal, at its lowest ebb. It is when we find the weed question becoming a part of a farmer's conscience, a part of his moral life, that we have great hopes for the future of that man's farm. This can come about only through the channel of education, by one means or another.

An observing farmer learns in two or three years the weeds that are most abundant upon his farm, and he learns also those that are doing him the greatest amount of damage. He can also learn the names of these upon inquiry, or they can be sent to the Experiment Station where information concerning them will be cheerfully furnished.

A piece of land is infested with a certain kind of weed which becomes more baundant than all other kinds. The method of rotation the farmer is using increases rather than decreases the weed. If he knows the habit of this weed he can change his rotation soon enough to prevent its becoming very abundant. If he knows the appearance of the seed, he will quit sowing grain containing that weed seed. An example came under the writer's observation a short time ago. A piece of land was infested with wild morning glory or bindweed. This weed is a perennial and spreads like the Canada thistle by means of deep seated, creeping underground stems. The land had been seeded for several years, which did not hinder the growth of the weed. By the middle of June the morning glory had almost complete possession of the field and from that time the wheat crop was doomed. Now the point is this: Had the farmer known the weed and the nature of it a few years ago, he could have gotten rid of the weed without much trouble, whereas today the ground is practically worthless and a large amount of labor will be necessary to get rid of it. If every farmer knew the Canada thistle on sight and kept a sharp lookout for it, many of the thistle patches could be gotten rid of easily, but the plants become deep rooted after four or five years and difficult to eradicate, whereas they can be gotten rid of by digging out once during their first or second years' growth.

METHODS OF ERADICATION.

In the first place, all weeds can be exterminated or can be reduced in number so that they are only moderately injurious to farming. To exterminate entirely many of the weeds would be a process for too costly for any ordinary farmer or set of farmers to undertake. It is the duty, however, for every farmer to reduce the number of weeds to the minimum.

ANNUALS.

The annuals or one-year weeds that will be considered include all those of first rank, some of lesser importance at the present time, but which promise to become important, and others about which inquiry has been made. As stated before the plants start from the seed in the spring; grow rapidly, blossom, seed and die the same year. One of the annuals, Frenchweed, may differ somewhat in its life history in that it germinates in the fall, lives through the winter and begins blossoming in March as soon as the snow leaves the ground. The seeds ripen in late May or early June, and these seeds will produce another crop of matured plants the same season. Such plants are known as winter annuals. Frenchweed, shepherd's purse and peppergrass are the most important winter annuals of this state.

TUMBLE WEEDS.

Two of the annuals, Russian thistle and tumbling mustard, have a peculiar way of distributing their seeds. When ripe in the fall, they break off near the ground and being somewhat of a spherical form they are blown hither and thither by the wind, distributing their seeds as they go. Such weeds are known as *tumble* *weeds.* Another plant, the common tumble weed, is a less important member of this group. These weeds are particularly hard to deal with, for no matter how clean a farmer may keep his fields, the seeds of these plants will be blown upon his land from surrounding areas, reseeding his clean lands year after year.

If the fields of a farm are fenced it aids some in keeping out these intruding pests. This is particularly true if the weeds are not too thick in the neighborhood. When very thick the triangle between the fence and the ground soon fills up and the succeeding weeds blow over the fence.

Sowing pure seed grain, while perhaps not so important as with other weeds, is yet very essential. A neighborhood may be practically free from tumbling mustard but if someone sows flax containing tumbling mustard seed, the whole township soon becomes infested.

TUMBLING MUSTARD.

The following method, with several variations, is used successfully by many farmers in North Dakota. Plow the land rather late in the spring thus allowing the weed seed to germinate previous to plowing. Sow heavily to barley and harrow once or twice with a rather light harrow when up. After the barley is removed, if many weeds appear in the stubble it may be burned. A little millet may be sown with the barley which will facilitate burning. This land should not be plowed until the following spring. Again plow late and put to wheat. Harrow after drilling and two or three times after the wheat is up. This method should produce a clean crop of wheat provided that clean wheat is sown, and that the plow did not bring to the surface a large number of ungerminated weed seed. The harrowing given to the wheat will certainly kill most of the young weeds. Those that do live will be choked by the growing grain. The wheat stubble should be burned, if possible, in the fall. Plow again in May and sow to oats or millet. If to millet cut for hay. If sown to oats cut for hay if the weather is dry and the weeds grow rapidly; if the field is quite clean the oats may be harvested. If it is necessary this stubble should be burned. Practice and theory show that if this method is wisely followed, varying the methods to suit the individual conditions, the land may be freed of tumbling mustard and most of our annual weeds.

***The Experiment Station does not advocate burning stubble under ordinary conditions, but in this case it is thought to be the lesser of two evils.**

This rotation is not ideal farming.* Its purpose is to clean weed infested land while growing crops. The principles of it are: do not grow flax; plow in spring; harrow the wheat when it is up; seed barley, oats or millet heavily, cutting when green for hay if necessary. In some cases if the weeds are very abundant, it may be advisable to cut the wheat when green, for hay, though this is not ordinarily necessary.

RUSSIAN THISTLE.

This is more difficult to deal with. It grows in lighter soils where the soil is apt to "blow," and hence harrowing the wheat is often detrimental. Perhaps the harrow followed by the roller would be valuable. Moreover it is believed the young Russian thistle plants are more difficult to harrow out than many other annuals. The sowing of oats or millet, and cutting these green for fodder is strongly recommended. The stubble should be plowed, or burned if possible, to prevent any of the thistles seeding. Spring plowing should be done when possible. Cultivated crops such as corn should be put in and *kept clean.* The Russian thistle furnishes fodder if cut green with the oats or millet and cured as hay. The large rolling plants usually grow in waste and vacant places. If careful attention be given to the eradication of these there will be fewer left to roll over the country. The plants that grow in a grain field are usually too small or too slender to roll much.

The points that need to be emphasized with the Russian thistle are the following: 1st, Pure seed grain. 2nd, The growing of clean cultivated crops. 3rd, Growing oats or millet for hay, cutting the same before the thistle ripens any seed. 4th, Stubble fields cleaned after the crop is removed by burning or by mowing and burning when dry. (The stubble may be plowed in fall, but do not plow under plants that are ripening seeds.) 5th, Plowing in late spring after the seeds have germinated. 6th, Harrowing the wheat or other crop after it is up.

THE REMAINING ANNUALS.

The seeds of the yellow mustard, Frenchweed, wild oats, etc., are not distributed so easily as the seeds of Russian thistle or tumbling mustard, and if the farmer clears his land of yellow mustard, etc., it is not so difficult to keep it clean. There are two things to be kept in mind. 1st, Sow clean seed. 2nd, Do not let any weed produce seed. The nearer a farmer can come to carrying out these principles the less weeds he will have. Remember the adage, one year's seeding means seven years' weeding.

SOW CLEAN SEED. To untrained eyes the seed grain may appear to be pure. Spread a handful of it out upon white paper and with a knife separate out only the seed grain. If weed seeds are present they will be left by themselves and thus one can readily tell if his seed is pure or not. The chances are much in favor of its being dirty. The prices of really good fanning mills are so moderate that a farmer cannot afford to be without the best. A good mill will remove entirely, nearly all kinds of foul seed. Cockle and wild buckwheat are difficult to remove but a good mill will largely eliminate even these.

PREVENT WEEDS SEEDING. This is to be accomplished by (1) harrowing or using weeders, (2) by plowing at proper times, (3) by seeding oats, barley or millet and cutting green and (4) by bringing into the rotation, cultivated crops. The use of these methods means two things: *more intensive cultivation and a quicker rotation of crops.* The above methods are to be supplemented by hand pulling, by burning stubble, by summer fallowing, etc.

If a farmer has repented and intends to reform; that is, if he intends to rid his land of weeds, the work should be done thoroughly and not in a half-hearted manner. In order to do this do not undertake to clean more land than can be done well. As much as possible of the remainder of the land should be seeeded down to grass. The sod will prevent most of the weed seed from germinating and some of the seed will rot. When part of the land is cleaned, the remainder of the farm in sod can be turned over and that portion cleaned.

It will not be necessary to discuss general methods in regard to annuals, more extensively. Methods of fighting the annual weeds differ with the various kinds and with the various soils. A method that will do well in valley land may be of little value on lighter soil. With a more thorough knowledge of weed conditions in this state it will be possible to give definite advice in regard to particular weeds and specific localities. At least some of the general methods given above will apply in all cases, but even a specific method must be followed intelligently. There are so many factors, known and unknown, entering into the weed question, so many new and unlooked for conditions arising, that it really takes more than a moderate amount of ingenuity to be quite successful. The eradication of particular weeds is discussed when treating of the different kinds.

PERENNIALS.

Canada Thistles and Quack Grass. After a perennial weed has once become established it is much more difficult to eradicate than an annual. It reproduces not only by seeds but by underground stems as well. These stems are found near the surface, or two or more feet deep in the ground, and when too deep for the plow are very difficult to get at. The underground stems can resist long periods of dry weather and the severest winter will not affect them. Perennial weeds are well prepared to lead thrifty lives. If a perennial is prevented from bearing seed it spreads very slowly over a field and is often very limited in area for many years. This much to the credit of the plant. If Canada thistle spread as rapidly as Russian thistle, annual weeds would not bother. There would be but one crop grown in North Dakota, and it would not produce figs either. A perennial weed can withstand a great amount of hard treatment, but in order to do this it must produce green leaves above the ground. If it cannot do this the life of the plant is doomed.

The underground stems of quack grass are near enough to the surface so that they can be reached by the plow and in certain seasons this plant can be attacked bv shallow plowing and thorough cultivation. In a wet season this method only serves to distribute it.

Before proceeding with a description of some of the worst weeds it will be well to touch upon a few outlying points.

YOUNG WEEDS DIE EASY.

Every one is familiar with the common purslane or pussley found growing in gardens. This is a fleshy prostrate plant and when full grown is very difficult to kill. Even when dug up and "thrown on its back" it will continue to blossom and ripen seeds nearly as well as in its normal state. When the weed is very young circumstances are different. When the weed is one-half inch high, 90 per cent of them can be destroyed by hand raking on a sunny day. Only a short exposure to the hot sun kills them. In another week less than 50 per cent of them would be killed by such treatment. In three weeks' time raking the purslane would injure it scarcely at all. As it is with the purslaneso it is with *all weeds*. They are easily killed when very young. It is for this reason that harrowing wheat or other grain just before and just after it is up is so valuable in killing the weeds. Their roots are small and have not yet secured a foothold in the ground and any slight disturbance of the ground loosens them and they die and die quickly. Because the young weeds are inconspicuous in appearance, they escape the eye of many persons, but these young weeds grow with fearful rapidity. The leaf surface of yellow mustard may nearly double itself in twenty-four hours and during that time the root sinks deeper into the soil, the plants become firmly anchored and difficult to eradicate. Young weed seedlings are also easily killed by covering. If a seedling having only its two seed leaves, be covered with dirt, the chances are much against its ever appearing above ground again. Grass seedlings are more difficult to kill in this manner, but a large number die when covered.

HARROWS AND WEEDERS.

It would be out of place here to discuss the relative merits of the various harrows and weeders. A few words will suffice. A spring tooth or discing harrow is generally considered more efficient than a smoothing harrow, to kill the weeds in a fall plowed piece or on summer fallow. In harrowing young grain, the lightest harrow that will do the work is obviously the one to select. It is desired and often necessary to go over a large area in a short time, while the weeds are still young or after a rain, so that a dust blanket may be formed quickly. The majority of the weeders are considered by many very good for this work. Two weeders are sometimes fastened end to end thus making one weeder 24 feet wide. With this one man can cover nearly fifty acres in a day. It is evident from what has been said that a weeder will do good work provided the weeds are young. Do not wait until you think all of the weed seed are sprouted for by that time the ones first sprouted will be too old and strong to be killed by the weeder. Going over the land twice will be doubly efficient.

Contiual discing of land rather than plowing increases the growth of wild roses, sunflowers, bind-weed and other perennials. Discing rather than plowing is undoubtedly of much advantage occasionally in clean land, but it is certainly poor policy if the land is badly infested with the above or similar weeds. The discs cut the underground stems of the weeds, generally in the growing season, and thus aids rather than retards, the growth of the plant.

SCREENINGS.

It is the best policy to raise the minimum amount of screenings. It is impossible to raise perfectly clean wheat. It is bad economy to raise dirty wheat, to be heavily docked for it and then to pay railroads for hauling it away 300 miles. Farmers should aim to grow less screenings and learn to use what they do grow, upon the farm. But if screenings are used whole or unboiled on the farm, it would have been nearly as good policy to have shipped them away. Screenings fed out unchanged, form a veritable hot bed of weeds for the rest of the farm. Most of the weed seed is small and very often has a hard seed coat as in the yellow mustard. A large proportion of weed seed will pass through the alimentary tract of an animal with their germinating powers unimpaired. Weeds grow up around the barn and house and from thence their seed are carried over the farm by wind or by other means. The seed from weeds growing near the stable is particularly liable to be spread. The seed becomes attached to the various farm implements or to the feet of the horses and are thus carried to the field. The seed of some of our worst weeds, tumbling mustard, for example, readily adhere to a foreign object when moist and thus forms one of the means of distribution. These waste places should receive particular attention in being kept clean.

WELL ROTTED MANURE.

As the years go on, more manure is applied to North Dakota land. This is applied either green or in a rotted condition. The rotted manure becomes more quickly available to the plants, does not dry out the soil in a dry year, and what concerns us most here, is not likely to contain weed seed capable of germinating. The difference in green and rotted manure in this respect is remarkable. If green or fresh manure is applied as a top dressing to clean land, there will be as many weeds on that land as though the weed seed had been carefully drilled in. The manure should be drawn to piles and allowed to rot, and when this has taken place the weed seeds are dead and the manure is in much better condition for the land. The manure should remain in the pile at least one year before being used.

WEED LAWS.

It is believed that the sentiment of the people would support a conservative and wisely enforced weed law. A stringent and drastic measure would fall of its own weight. North Dakota has a weed law—longer than that of any other state—but because of its complexity and its technical defects, it is scarcely any value. Manitoba and Assiniboia have weed laws which are continually being put into force. A weed inspector travels over the territory educating farmers about weeds and methods of extermination, and advising local inspectors in regard to their duties. A list of weeds is prepared which are known as Noxious Weeds. When noxious weeds are not cut, notices are served upon the occupants or owners of land that the work must be done. Much care is given to the cutting of weeds on unoccupied lands. Attention of the farmers is continually drawn to the fact that it is for *their* interests that the law is being enforced. In nearly all cases the farmers are willing and anxious to comply with the spirit and letter of the law.

The North Dakota law is planned along much the same lines as this. It could be easily modified as to be of real value to the state. All must be agreed that it is of no value at the present time. Incorporated in the weed law should be provisions making it a misdemeanor to sell garden or farm seeds containing foul weed seed. This state has enough weeds, but there are many eastern ones that happily are not here yet and any measures directed toward keeping them out should be encouraged.

DISADVANTAGES OF WEEDS.

1. They rob cultivated plants of nutriment and moisture.
2. They injure crops by crowding and shading.
3. They retard the work of harvesting grain by increasing the draft and by extra wear of machinery. (Bindweed, thistles, kinghead).
4. They retard the drying of grain and hay.
5. They increase the labor of threshing, and make cleaning of seed difficult.
6. They damage the quality of flour, sometimes making it nearly worthless. (Cow cockle, corn cockle).
7. Most of them are of little value as food for domestic animals.
8. Some weeds injure stock by means of barbed awns. (Squirrel tail, wild oats, porcupine grass).
9. Some of them injure wool and disfigure the manes and tails of horses. (Burdock, cockle bur, wild liquorice).
10. A few make hair balls in the stomach.
11. Some injure the quality of dairy products. (Leeks, wild onions).
12. Water hemlock, death camas, and swamp camas are very poisonous.

13. Frenchweed, and probably others, when eaten by animals, injure the taste of meat.

14. Many weeds interfere with a rotation of crops.

15. All weeds damage the appearance of a farm and render it less valuable. (Quack grass, Canada thistles, Russian thistles).

SOME SMALL BENEFITS.

1. They are of some use in the world to induce more frequent and thorough cultivation, which benefits crops.

2. The new arrival of a weed of first rank stimulates watchfulness. (Russian thistle).

3. In occupying the soil after a crop has been removed, they prevent the loss of fertility by shading the ground.

4. Weeds plowed under add some humus to the soil, though in a very much less degree than clover or peas. (Adapted from Dr. W. J. Beal).

WEEDS OF SPECIAL INTEREST.

It is not possible, and probably at this time not desirable, to describe all of the weeds of North Dakota which aggregate 150 or more. A few were selected for description, either because of their importance or because of numerous inquiries made in regard to them. A few of them are not abundant enough to cause any great damage. Such weeds, however, have become serious pests in other states and promise to become so here. It is essential to put farmers on their guard against them. The weeds of first rank, those that do the greater amount of damage are about nine in number. They are: Pigeon grass, wild oats, quack gras, wild buckwheat, Russian thistle, tumbling mustard, yellow mustard, French weed and Canada thistle. Not all of these are found over the entire state, but where found, they make their presence known.

PIGEON GRASS. YELLOW FOXTAIL. WILD MILLET.

This introduced weed is found almost everywhere in cultivated ground. It is particularly abundant in grain fields, potato patches and gardens. It is an annual and germinates about the first of May. When young it can be told from all other grasses except cockspur, by its rather wide leaf and the reddish color of the stems near the ground. The heads of this grass resembles those of Italian and other similar millets, but are somewhat smaller.

The seeds are yellowish, oval and rather hard. They are easily removed from wheat, but are difficult to remove from flax seed. This weed is present under the most careful methods of farming. All that can be done is to reduce its ravages to a minimum. Pure seed grain is an efficient factor here as elsewhere. Early seeded grain gets started ahead of this weed. Later seeded grain should certainly be harrowed—even if this weed were the only one. The weeders do this work very well. This plant produces a fair quantity of forage in dry years. Quite a good deal of it was cut in 1900 for hay which was of fair quality. Green foxtail with smaller seeds grows here, but is apparently less common.

WILD OATS.

This is a bad weed of the first rank. It is an annual and most abundant in the eastern portion of the state, especially in the Red River Valley. The plant and the grain resemble that of the cultivated oats. *The grain has a horseshoe shaped ring of hairs at its base,* it is yellow or blackish in color and bears on the back a blackish, twisted and bent awn about one inch long. The grain is of light weight. The wild oat plant is quite different from porcupine grass found on the prairies. This has a twisted awn six inches long. The latter is often wrongly called wild oats. Wild oats ripen early, shell easily and probably remain in the ground many years without germinating, at least when the ground is dry. Wild oats germinate when three or four inches underground. The plant has narrow leaves so that harrowing the young crop is not of the greatest value. *Wild oats can never be gotten rid of if the land is cropped continuously.* Farmers have succeeded in removing wild oats from their land in a variety of ways. Perhaps the following is one of the most thorough methods: Plow the ground shallow in the fall after the crop has been removed. In the spring plow the ground deep and summer fallow that season, keeping the ground clean, mainly by aid of the spring tooth harrow. Grow a crop of flax or barley the next season, but do not plow the summer fallow. Pull the few wild oats that may be found in the barley or flax. Plow deep early in the fall. Summer fallow the piece clean next year in the same manner as before and put the summer fallow to wheat or barley the year following without plowing, harrowing the ground well before seeding. The upper six or seven inches of soil has thus been put in the best possible condition to germinate the wild oats seed in the ground, and if there is any left to germinate later they can be easily pulled.

This method calls for an extra summer fallowing but the fact that the land is freed from wild oats should repay the extra work.

The following method is suggested and while not so thorough as the preceding, yet it is sufficient in many cases. After the wheat or other crop is removed, plow the ground very shallow as soon as possible. Plow early and deep in spring, and harrow at least three times with spring tooth harrow or twice with spring tooth and once with discing harrow, at intervals of one week or more. Sow to barley upon the clean seed bed some time in the latter part of May. Cut the barley for hay, or if the wild oats are not much developed cut for grain. Fall plow deep, harrowing in spring as before and put into millet, cutting it for hay. Plow shallow in fall, harrow well in spring before seeding and put into corn or wheat. Harrow the wheat or corn when up. If any wild oats appear that season, pull.

If more land is infested with the wild oats than can be treated in one year it is strongly advised to put part of the land to grass for two or three years. In the second method given above the land may be seeded to grass or clover, using the last wheat crop as a nurse crop.

SWEET GRASS. VANILLA GRASS.

This is a native perennial grass, spreading by means of its deep unerdground stems, and easily known by the sweet odor of its leaves and stems. It produces its brownish panicle of sweet-scented flowers in May. It has no forage value because it is not liked by stock. The method of eradication used in Manitoba is to plow deep when in flower and seed heavily at once. We would suggest plowing early and deep, prepare a good seed bed and seed to Hungarian millet and brome grass, or to oats and brome grass. Of the millet sow about three pecks and of the oats five pecks per acre. The oats or millet prevent the sweet grass from getting a start, and if the brome grass succeeds in getting a good start it will be very apt to smother the sweet grass entirely.

This grass is called "quack grass" by many people. To give it this name only causes confusion. Sweet grass is an easy name and distinctive and should be used.

QUACK GRASS. COUCH GRASS.

A plant nearly identical with this, found in the river bottoms of the west, is known by the ranchmen as "Blue Grass." Quack grass is a valuable forage and hay grass, but because of its persistent underground stems it is difficult to eradicate when the land is desired for cultivation. These stems are easily reached by the plow. This grass must be handled in a dry season. The land is plowed shallow and cultivated continuously, and the next season is seeded heavily to brome grass. When the brome grass is cut for hay, the sod is broken and backset in the fall. This is followed by grain or by a cultivated crop or wheat. Small areas may be killed by smothering.

DOCK. WILLOW LEAVED DOCK.

This perennial is too well known to need description. There are several species in the state, but the one named above is probably of greatest economic importance. It is most troublesome in wet hay lands. It is a perennial plant with long tap roots. When the ground is moist it should be pulled and placed in heaps. When dry these should be burned. A field can be practically freed of the plant by following this method three or four years.

WILD BUCKWHEAT. BLACK BINDWEED.

This well known annual is found everywhere in the state that cultivation has been carried on. It has a twining or trailing stem, the leaves approach the triangular in outline, the flowers are inconspicuous, but the seeds (achenes) are one-eighth inch long, three-angled and dull black. The seed is difficult to remove from wheat; it requires a good mill. As the seed is large, it grows when buried three or four inches. This plant produces a large amount of foliage in a short time and so suffocates the growing crop. There is no infallible rule for the treatment of this weed. It does the least damage to those farmers that pay careful attention to pure seed, intensive farming and good rotation. A cleanly cultivated corn crop or millet is always good. It would require extreme care to eradicate it entirely from a farm.

PIGWEED. LAMB'S QUARTERS.

Although, perhaps not a weed of the first importance, yet because of its abundance and its fleshy character, it absorbs a large quantity of moisture and nutriment when growing rapidly. The seed is nearly always found in dirty grain, but it is small enough to be easily separated. This plant is greedily eaten by hogs and sheep and may be used to clear ground Cultivated crops are valuable in killing the weed.

WILD BARLEY. FOXTAIL. FLICKERTAIL.

This grass, which is related to the field barley, is easily recognized by its habit of invading lawns and pastures and by its long spreading awns. The awns are very injurious in hay. The leaves and stems are bluish-green and covered by soft hairs. The nodding heads resemble those of common barley but are softer and the awns smaller. They are yellowish in color and purplish in cooler weather. This plant is eaten some by stock when young but is not willingly touched when the heads appear. Thus the grass is a positive damage to pastures. The awns injure the lining of the alimentary tract of an animal when taken in as part of the hay. They also find lodgment between the teeth of animals and gradually work their way farther in setting up inflammation and ulceration causing the teeth to drop out in many cases. Inflammation may continue until the greater part of the jaw bone becomes diseased. This has been well shown by Professor Nelson of Wyoming.

This grass is difficult to get rid of. When practicable it should be cut before the heads ripen and then burned. If necessary it should be recut. If much of it is found in a field the ground should be broken in June, cropped and seeded to brome grass. It is easily killed by plowing but the land soon becomes reseeded by the wind. It bothers worst in overstocked pastures.

WILD MORNING GLORY. HEDGE BINDWEED.

This well known perennial vine has white, fleshy, underground stems and large, white or pinkish flowers similar to those of the cultivated morning glory. It spreads like the Canada thistle. No experimental work has been carried on with this plant at the station. If it becomes well established it may be necessary to summer fallow, plowing twice, keeping the ground clean. If the area covered by the morning glory is not too extensive, the white underground stems should be shaken out by a fork after plowing and allowed to die. A small patch is easily killed by smothering with straw.

RUSSIAN PIGWEED, AXYRIS. (Plate I, Fig. 1.)

This plant has been found only in Cavalier and Pembina Counties. It was introduced from Manitoba and earlier from Russia, and is slowly but surely moving southward. It is an upright

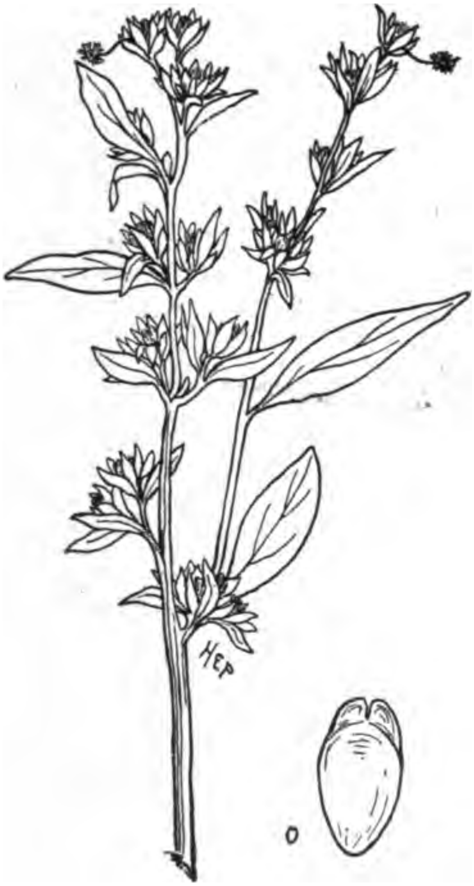

Fig. 1.—Russian Pigweed. Portion of plant showing leaves and flowers and also seeds. Branch twice natural size; seeds much enlarged.

branching annual with alternate green leaves with clusters of seed bearing flowers near the axils of the leaves. The flowers are inconspicuous. The seeds are about one-sixteenth of an inch long, flattish, gray or mottled and most of them are provided with two minute wings at one end. The plant is a native of Russia and Siberia. Because of its abundant seed production and congenial surroundings it takes complete possession of the land. At the present time this plant seems to favor waste places, but there is no known reason for its not invading grain fields, and in fact seed barley has been examined containing the seed of this pest. To all appearances this weed promises to be as bad as the now famous French weed that invaded the state by the same route. If taken in hand now this weed could be checked by a moderate outlay of time and money, but if left to spread, as it is doing, it will eventually cost the farmers an enormous sum. With an efficient weed law, in charge of an inspector, it would be the business of some one to look after the pest while now it is no one's business. A matter of this nature is really just as important in its way as an epidemic among live stock and it would pay in the long run to handle it as summarily. It is believed that with the experience gained with Russian thistle and tumbling mustard, the farmers of North Dakota would welcome a law that would make it possible to prevent the entrance of such fearful pests. The time is certainly ripe for action.

RUSSIAN THISTLE. RUSSIAN CACTUS. (Plate II.)

This famous weed is too well known over the light soils of the state, but in the Red River Valley region it is scarce. The plate shows very well the characters of this plant. When young it is dark green with soft, narrow, awl-shaped leaves. As the leaves become older they devolp prickles on their ends wihch fact, coupled with the home of the plant, gives it its name. It is related neither to the thistles nor to the cacti, but is a near relative of the pigweed. The plant is killed by frosts, and when dry is tumbled about by the wind. The best means of repression are: cultivated crops and clean summer fallow; cutting oats or millet containing it, for hay; firing wheat stubble; and cutting plants in waste places. Plants in waste places are apt to form the big "rollers" which do so much in distributing the seed. This plant need not be feared in thickly settled communities if the land is handled correctly. See page

PINK COCKLE. COW COCKLE...COWHERB. (Plate III.)

This annual is found in grain fields over the larger portion of the state, especially outside of the Red River Valley. It is one to three feet high with a spreading top, bearing a large number of pink flowers one inch in length. The leaves are very smooth and opposite to each other on the stem. The seeds are nearly black, spherical, roughened and about twice the size of mustard seed. Because of the difficulty of their removal from wheat, their presence "cuts" the grade. The seeds are poisonous and flour made from wheat containing these seeds is injurious to health. Because of the color of the flowers, this plant is easily recognized in grain fields and when not too abundant, should be pulled. It would probably pay to pull even if abundant. Practically all of the seed is gathered with the grain. If the seed used contains no pink cockle seed, the weed can be easily eradicated provided a good system of rotation be followed.

COCKLE. CORN COCKLE.

This annual is closely related to the preceding, but it differs in that it has very narrow hairy leaves and fewer, larger, handsome purple flowers. The pod is swelled and contains many black, nearly round, grooved and pitted seeds. The seeds are larger than those of pink cockle and their presence in wheat is easily noticed. Because of their size, the seeds are difficult to remove from wheat. It takes a good mill to do the work. This plant has grown in wheat from time immemorial and it has gotten so it feels at home only there. The seeds of this plant are poisonous like the preceding. The plant is conspicuous on on account of its flowers and should be pulled. Ordinarily it is not very abundant in grain. It only takes a omparatively small amount, however, to cut the grade.

ROQUETTE...(*Eruca sativa.*)

NOTE.—This weed, with the seven following and many more found growing in the state, belong to the Mustard family, a family prolific above all others for the number of weeds contained.

The seed of this weed is imported with Turkestan alfalfa. It is a mustard somewhat similar to wild mustard. It has a strong odor. It is a bad weed and should be pulled whenever found.

FALSE FLAX. (Plate IV.)

False flax is found in nearly all parts of the state. It is an upright annual 2 to 3 feet high, spreading at the top when in fruit. The flowers are light yellow, scattered along the upper part of the stem and not very conspicuous. The pods are pear shaped and resemble a flax boll. Each pod contains several yellow, oblong seeds about one-tenth of an inch long. Each has two grooves which lie parallel and adjacent to each other. When moist the seed becomes sticky and is thus carried from one place to another. This plant does not seem to be generally recognized by farmers, and but few seem to know it by any name. This is caused, no doubt, by its confining itself largely to flax fields, and because it resembles flax closely when ripe. That it is abundant is proven by the fact that of the several hundred flax samples sent to the station from different parts of the state, more than half contained false flax seed. In 1903 an 80-acre field near Devil's Lake was occupied almost entirely by this weed. Such a field should be cut early in July, the weeds raked and burned. Plow shallow and summer fallow. The next season sow early barley, cutting for grain. Mow the stubble if necessary. Grow oats or millet for hay the next season or possibly wheat. Do not grow flax.

The cut, Plate IV, gives a very good idea of the appearance of the leaves and fruit of this plant. Careful cleaning of flax seed removes a large proportion of the weed seed. Continual "flaxing" of land increases the weed very rapidly. With proper rotation and clean seed the weed does not bother much.

HARE'S EAR MUSTARD. (Fig. 2.)

This plant is an annual infesting grain fields particularly, and found abundant in waste places. It is sometimes wrongly called black mustard. It is distributed over nearly the entire cultivated area of the state. The plant grows two to three feet tall. The leaves are bluish-green, thick and fleshy and attached directly to the stem, having no stalk of their own. The flowers are creamy-white or cream-yellow in color. The pods are about four inches long, one-eighth inch in diameter, nearly square in cross section and may contain fifty or more seeds. The seeds are dark brown in color whitened by the presence of very minute hairs. The seeds are about the same size and shape of the seeds of false flax. The presence of the hairs makes them rough so they are more difficult to clean from wheat and flax. It is said to be very difficult to separate the seeds from wheat and oats and more difficult still to clean flax seed when this mustard seed is present. Because of its abundant and fleshy foliage, this plant entails a heavy drain of soil moisture and fertility, just at the time when they are in greatest demand. It is a heavy seed producer. This plant is quite easily recognized, soon wilts and is not difficult to pull. Plants pulled in June do not con-

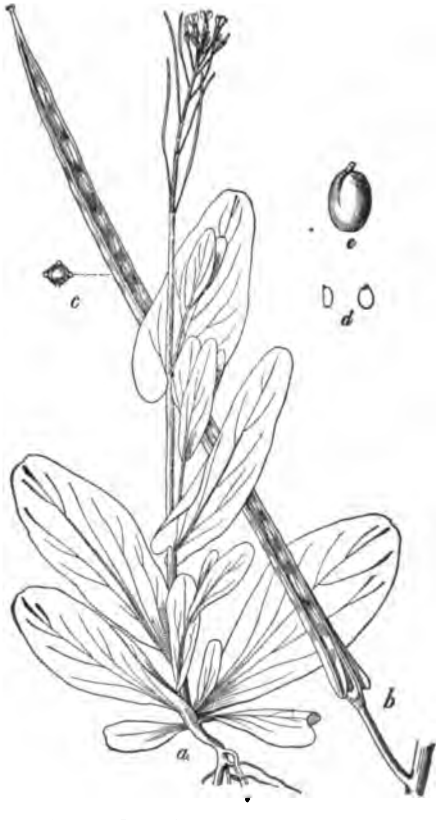

Fig. 2.—Hare's Ear Mustard. *a*, young plant, ⅓ natural size; *b*, mature seed pod with valves breaking away at the base, natural size; *c*, transverse section showing seed crowding septum to one side, natural size; *d*, seeds, back and side views, natural size; *e*, seed, enlarged three diameters. After L. H. Dewey, U. S. Dept. Agr.

tain seeds mature enough to ripen. The same rules apply to eradication here as with other annuals. This plant is easily killed by harrowing the young wheat.

TUMBLING MUSTARD. (Figs. 3, 4 and 5.)

This weed, sometimes called white mustard, is most abundant in the lighter soils of the state. In the flaxed fields of the central portion of North Dakota it seems to take almost complete possession. The flowers are nearly white or faint yellow in color. The leaves are oblong in shape shape and cut toothed as shown in Fig. 3. The pods, Fig. 4, are long and very slender, and contain over 100 seeds. The seeds are very small, about 1-25 of an inch long and half as thick, varying in color from reddish yellow to yellowish green. They are the size of a naked timothy seed. The plant becomes very bushy if allowed room to develop. It dies in September, after the hard frosts and after breaking loose from the ground is rolled hither

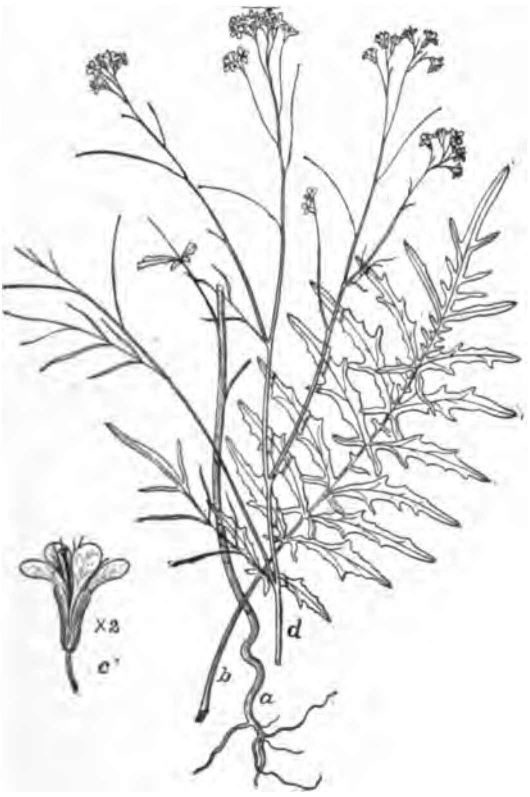

Fig. 3.—Tumbling Mustard. *a*, base of stem of annual plant; *b*, leaf from lower part of main stem reduced one-half; *c*, flower, twice natural size; *d*, branch with flowers and upper leaves, one-fourth natural size. After L H. Dewey, U. S. Department of Agriculture.

and thither by the wind. A well devolped bushy plant may travel 10 or 15 miles in a day if it meets with no obstruction. The seed is not easily released from the pods and so a plant will stand a good deal of hard pounding before all of the seeds are entirely distributed. According to Dr. Fletcher of Canada a single large plant may contain as many as 1,500,000 seeds. One plant under favorable circumstances could seed five acres in a day, giving seven seeds to each square foot. It is certain that no other plant in this state and perhaps in any state, has power to reproduce itself more abundantly. A man that spends a moment killing a tumbling mustard plant this year may thereby save a week's work and several bushels of grain the coming year.

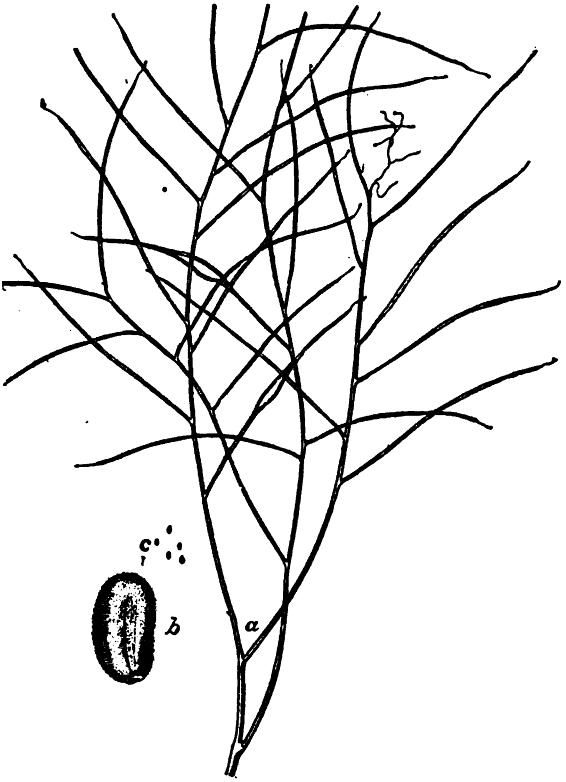

Fig. 4.—Tumbling Mustard. *a*, branch of mature plant with pods, one-fourth natural size; *b*, seed, enlarged; *c*, seeds natural size. After L. H. Dewey, U. S. Dept. Agr.

This plant may well be dreaded by the most careful farmer. No matter how clean he may keep his field, his neighbor will seed it for him. And yet vicious as this plant is, it need not be particularly dreaded if farmers of a township or county band together and fight it. The seed is small and can be easily separated from flax and grains. When removed it should be burned. The plants in waste places should be destroyed. It is these that furnish the tumblers. The stubble should be burned in the fall. Plowing should be done in the spring. Wheat or oats should be sown rather than flax. Millet or oats or both should be sown as part of the rotation and cut green. Cultivated crops should be put in. If these prinicples were to be followed by the farmers of a county, tumbling mustard would lose most of its terrors.

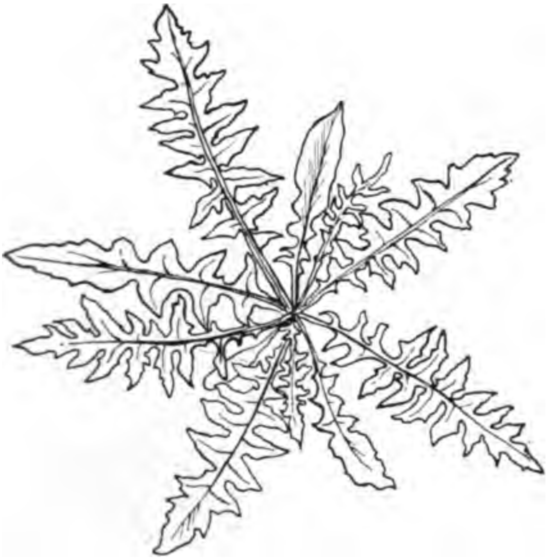

Fig. 5.—Tumbling Mustard, Seedling.
(After Dr. Fletcher, Department of Agriculture, Can.)

Fig. 5 shows a tumbling mustard seedling and at this stage it is easily killed by the harrow.

YELLOW MUSTARD. WILD MUSTARD. (Fig. 6.)

This plant, it may be said with regret, needs no description for North Dakotans. There is scarcely a cultivated field in the state that has not made its acquaintance at some time or another. In too many fields it has squatted, evidently for good.

If a field is not devoted entirely to the mustard, it should be pulled, not one year but every year. When the mustard is too thick to raise a crop, cut the mustard when in full bloom, rake and

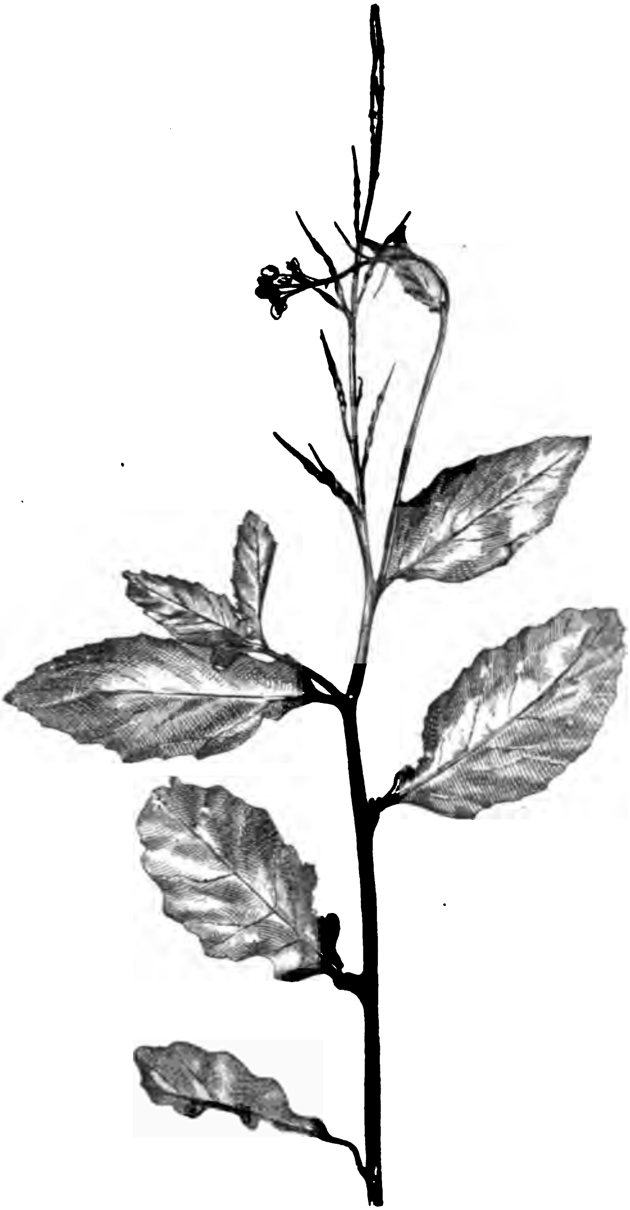

Fig. 6.—Yellow Mustard. (½ natural size)

remove from the field. Summer fallow clean that season. The next year grow millet and oats; cut green. Try a crop of corn the next year keeping it clean. Put the corn stubble to wheat without plowing. Each year pull all mustard that has any chance to go to seed. When a fresh batch of mustard seed is plowed up the ground should be put to corn or to millet rather than wheat or flax. If your mustard infested area is too large to handle at one time, seed a portion of it to brome grass,—the mustard seed will wait for you.

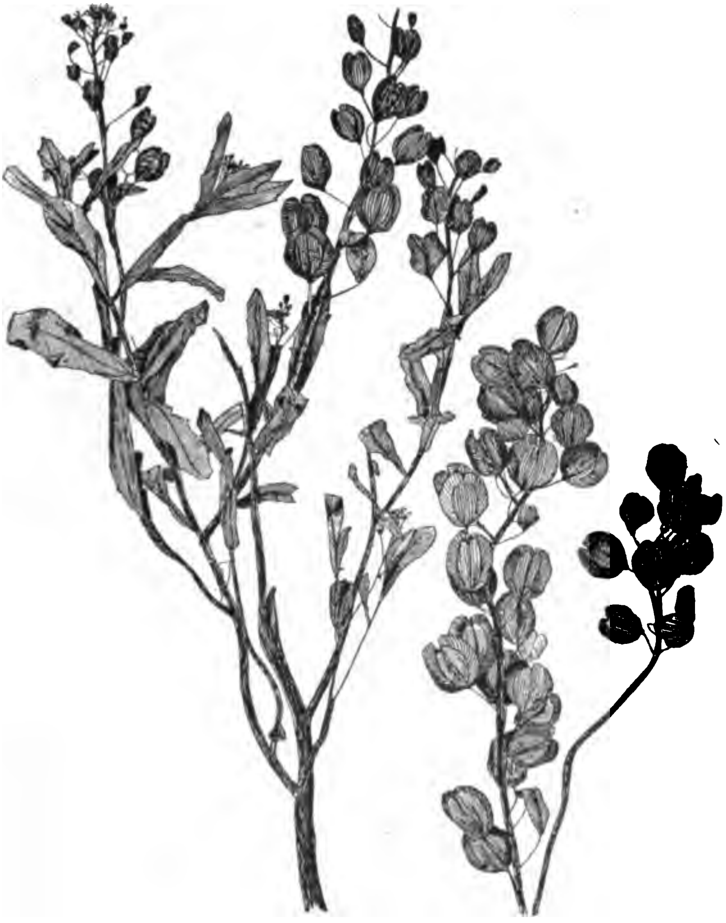

Fig. 7.—French Weed. (½ natural size.)

FRENCH WEED. PENNYCRESS. STINKWEED. (Fig. 7.)

Vicious and abundant as this weed is in the Red River Valley, many farmers do not know it even when growing on their own farms. A still larger number do not know it as a seedling. It germinates either in the fall, lives over winter and ripens seed in the spring, or germinates in the spring, maturing the same season. The pods are flat winged, one-half inch in diameter and contain about sixteen brown seeds one-tewlfth inch long. The plant varies from two inches to nearly three feet high and bears from 1 to 5,000 pods. It seeds in dense timothy sod nearly as well as in untouched summer fallow. It thrives in waste places, it is at home in the flax field, it revels in the wheat field. It is a hail fellow anywhere it may be found. It is this fearful pertinacity and abundance where found that make this weed the terror of the careful farmer. The small white flowers make it inconspicuous compared with yellow mustard, but it can be easily found in the crop doing its share of injury. Farmers are pretty well agreed that pulling yellow mustard is an essential factor in its eradication. The pulling of French weed, it seems to me, is just as essential but much more difficult. In general, it should be treated as yellow mustard.

SHEPHERD'S PURSE.

French weed is often given this name. The pods of Shepherd's purse are much smaller and triangular in outline. It is abundant in waste places and in dooryards. At times it is a bad weed in fields though not so bad as French weed. Like French weed it is a winter annual. The seeds resemble those of tumbling mustard. Treat in the same manner as yellow mustard.

PEPPERGRASS. (Fig. 8.)

This weed is found everywhere, but is most injurious on the lighter soils. The pods are circular and small, one-twelfth inch in diameter. They are very numerous, forming an oblong raceme 6 inches or more long. The seeds are similar to those of Shepherd's purse, but have a narrow wing. This is a winter annual and fall plowed lands should be harrowed twice in the spring, early and later, just before seeding. Seed grain containing peppergrass seed can be easily cleaned. The treatment generally should be the same as for yellow mustard.

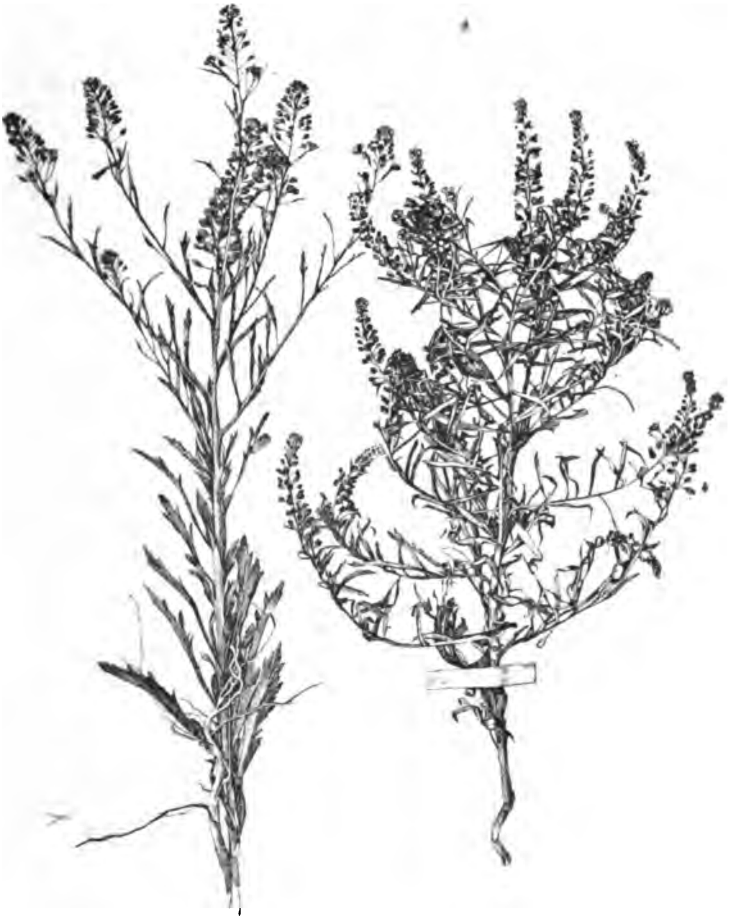

Fig. 8.—Peppergrass. (½ natural size.)

BALL MUSTARD.

This annual plant is found in the northeastern portion of the state. It is spreading southward. The flowers are yellow. The plant is so named because its pods are spherical. They are small, being only one-twelfth inch in diameter. The pods, the so-called "seeds," ripen and fall before the grain is cut This makes it difficult to deal with. Hoed crops must be grown. It is difficult to recognize in wheat, so pulling cannot generally be carried on, but it should be done as much as possible.

NYCTELEA (*Nyc-tel-e-a.*) (Plate V.)

This plant is native to the state and acts as a rank weed since the prairies were broken. It is noxious in the Red River Valley in wheat fields. It germinates early, makes a quick, rank growth and dies about July 1st. It is a low, vile smelling plant with toothed leaves and conspicuous fruit. The pod contains only four seeds. It can be easily recognized by a refernce to Plate V. The seed is never found in seed grain. The best remedy is to harrow the young wheat.

GREAT RAGWEED. KINGHEAD.

This plant is an annual and attains a height of six or even eight feet. Its leaves are large and deeply cut. It is best known on account of its "seeds" or achenes. These are light in weight, yellowish or brownish, ¼ inch long and have an encircling row of projections whence the name "Kinghead." These seeds are so difficult to remove from wheat that their presence in any quantity causes the grade to be reduced. The writer has seen it so abundant in wheat that probably 30 per cent of the threshed grain was composed of kinghead. It seems to infest crops more particularly in low lands. The plants should be pulled the latter part of June or early in July before the seeds have formed.

PRICKLY LETTUCE. COMPASS PLANT.

This annual resembles the garden lettuce, but it is taller and the leaves have prickly margins and the midrib of the leaf is prickly underneath. The leaves are twisted and directed almost vertically. They tend to point north and south whence the name "Compass Plant." The juice is milky. The flowers are yellow or sometimes blue. The "seeds" or achenes are provided with a little parachute of white hairs similar to those of the dandelion, which aid in traveling. This plant is rapidly becoming a bad weed as it is a rank grower and an abundant seed producer. The seeds are easily carried long distances which adds to its injurious nature.

This is more or less injurious in meadows as it seems to be able to seed in sod. It is also common in grain fields. The plants should be cut close to the ground wherever possible and burned. When abundant, it should receive the same treatment as other annuals.

BUCKBRUSH. WOLFBERRY.

This native perennial plant is found everywhere on the wild prairies and is often common in cultivated fields. It is a small shrub with dark green leaves and pinkish flowers, the latter bearded inside. It spreads by underground stems. Fields infested with this plant should be plowed early, kept well cultivated, and plowed again in the fall. The ground should be well plowed, care being taken to plow deep and cover the plants well. Well cultivated crops are valuable in eliminating this plant.

CORN SOW-THISTLE. MILK THISTLE.

This plant is from two to four feet high, perennial by deep roots and creeping rootstocks. It has many heads of bright yellow flowers one inch broad, similar to those of the dandelion. The seed are carried by the wind. The weed appears to be very bad in the northeastern portion of the state. It should be treated the same as Canada thistle.

MARSH ELDER. HIGHWATER SHRUB.

This annual plant resembles the kinghead and often grows to a height of 8 feet. The leaves differ from those of kinghead in being merely toothed and not lobed and in having a velvety feel due to soft hairs. The seed of this plant is small and black, very different from those of kinghead. Marsh elder is found in rich places, around buildings, along the roadsides and in fields. It exerts a heavy drain upon soil moisture and nutriment. If a field contains many plants it should be well cultivated for a season or two and when a grain crop is raised the plants should be pulled. If the plants are very thick they may be cut. Seed grain should be carefully examined before using to see if it is free from the seed of the plant.

CANADA THISTLE. (Figs. 9 and 10.)

The aggressiveness, the rank growth, the ease of seed distribution, the increase of the plant by underground stems and the spiny leaves make the Canada thistle dreaded above nearly all other plants, where known.

This plant although the last described is far from the least in importance. It is a true thistle and is distinguished from the prairie thistle by the leaves being darker green, without prickles or hair on their upper surface, and with the heads having no prickly spines. It grows in very dense patches. It is held by some that this plant does not bear seed capable of growing. This is certainly not true for North Dakota.

Although this plant grows from its underground stems and when cut off, repeats the process yet its life depends ultimately upon the green leaves it produces above the ground. The green leaves constitute the stomach of the plant, as it were, and as long as these are present the plant will grow and add new material to itself. A portion of this new material will be stored in the underground stems as reserve food material. If the stems of the thistle above ground — the aerial stems, are cut off, the thistle plant draws upon its reserve food material for the production of new leaves. If aerial stems continue to be cut off there comes a time when the reserve food material becomes exhausted and no more leaves can be produced. The method of killing the thistle consists in preventing the plant producing green leaves until its reserve food is exhausted. This may be done by continuous cutting, by smothering or by cultivation.

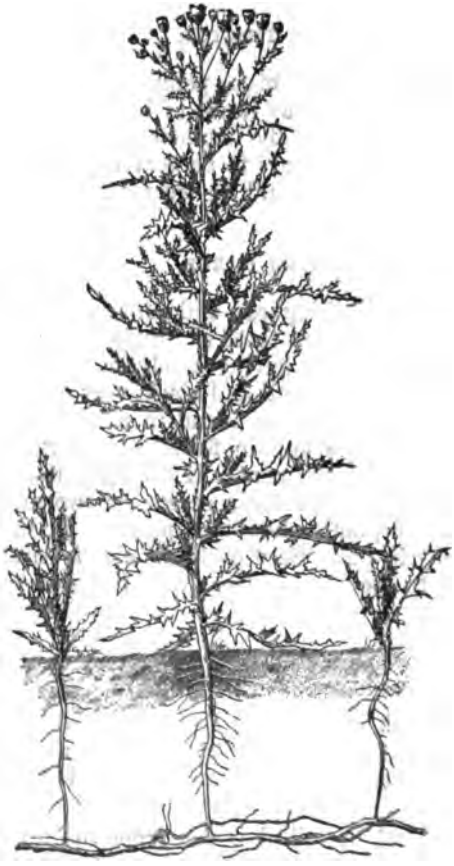

Fig. 9.—Canada Thistle, showing horizontal underground stems, young thistles and mature plant in flower. After L. H. Dewey, U. S. Dept. Agr.

Canada Thistle Experiment. But little experimental work has been done with the thistle in North Dakota. In the summer of 1902 a patch of Canada thistle of about five square rods was found and work was begun on them. They were cut while in full bloom, Aug. 4th, and burned. The method selected was to cut them at short intervals until the underground stems were too weak to produce new plants. The thistles in the patch seemed to as thick as they could grow. Owing to the absence of the writer from the station they were not cut again until Sept. 5th. Many thousands were then up. It required one-half day to cut them and rake them off. Sept. 19th 200 were cut; Oct. 21st, cut 1,000. The following number, approximate, were cut during the first half of the season of 1903:

May 1st	112	June 20th	800
May 8th	700	June 22nd	450
May 15th	1700	June 26th	250
May 19th	500	June 30th	250
May 22nd	250	July 5th	100
May 26th	500	July 7th	50
May 30th	800	July 10th	35
June 2nd	400	July 14th	25
June 13th	2000	July 17th	15
June 17th	800		

It took twenty-eight hours of time to do the required labor. The number of cuttings was twenty-three. The drouth accounts for the less number at the later dates, but it is possible that the spirit of the thistle was broken. They will not be killed out, however, until no more thistles are found,—that is, a sick patch is by no means a dead patch.

It is a good plan to place a pile of straw or manure, the latter three feet deep upon a small patch, but if the thistles are in blossom they should be cut and burned. It is believed that seeding the ground thickly to brome grass after a season of thorough cultivation and hoeing would be effective in keeping them down and perhaps be a long step toward eradication. Even if a man does not think himself capable of eradicating his patch of Canada thistles, he should realize that he has a duty toward his neighbor and *keep them cut,* not allowing them to go to seed.

ERADICATION. Below is given a summary of an experiment conducted by Professor Burrill of Illinois upon the extermination of Canada thistle. It shows conclusively that they can be eradicated there without a great deal of difficulty. It is very certain

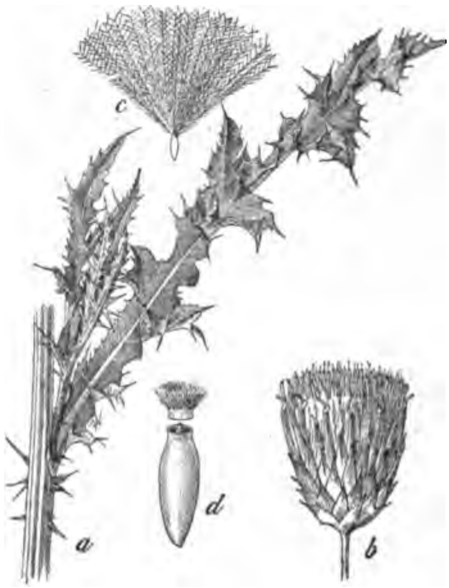

Fig. 10.—Canada Thistle. *a*, main stem and leaf; *b*, flower head; *c*, seed with pappus, natural size; *d*, enlarged with pappus attached. After L. H. Dewey, U. S. Department of Agriculture.

that the same plan or a similar plan can be carried on here to equal advantage. The station would undertake this work immediately if any thistles were growing upon its cultivated land. It is highly desirous to co-operate in this work with some farmers, and if one will volunteer we will gladly furnish directions for the work. Thistles are gaining such a foothold in certain parts of the state that it is high time time for the battle to begin.

The experiment was as follows: The thistles covered two and a half acres very thickly, of rich black prairie soil. The thistles were cut July 17th when in full bloom, very close to the ground. The ground was plowed three inches deep and harrowed. Hungarian millet was sown at the rate of one bushel per acre. On September 10th the millet was one foot high and the thistles four or five inches high. It was turned under and harrowed. October 8th the ground was plowed again, harrowed and seeded to winter rye at the rate of one and a half bushels per acre.

The middle of the following April the rye was turned under and the ground thoroughly harrowed. The ground was plowed May 25th and again June 25th. On May 25th very few plants could be found. July 14th the ground was seeded to millet, which was cut for hay September 15th. Less than fifty plants were found on the two and half acres during the latter half of the season. The net total cost of this victory was only $10.50 per acre. That outlay really meant a purchase of the land for it was of no value until the thistles had been exterminated.

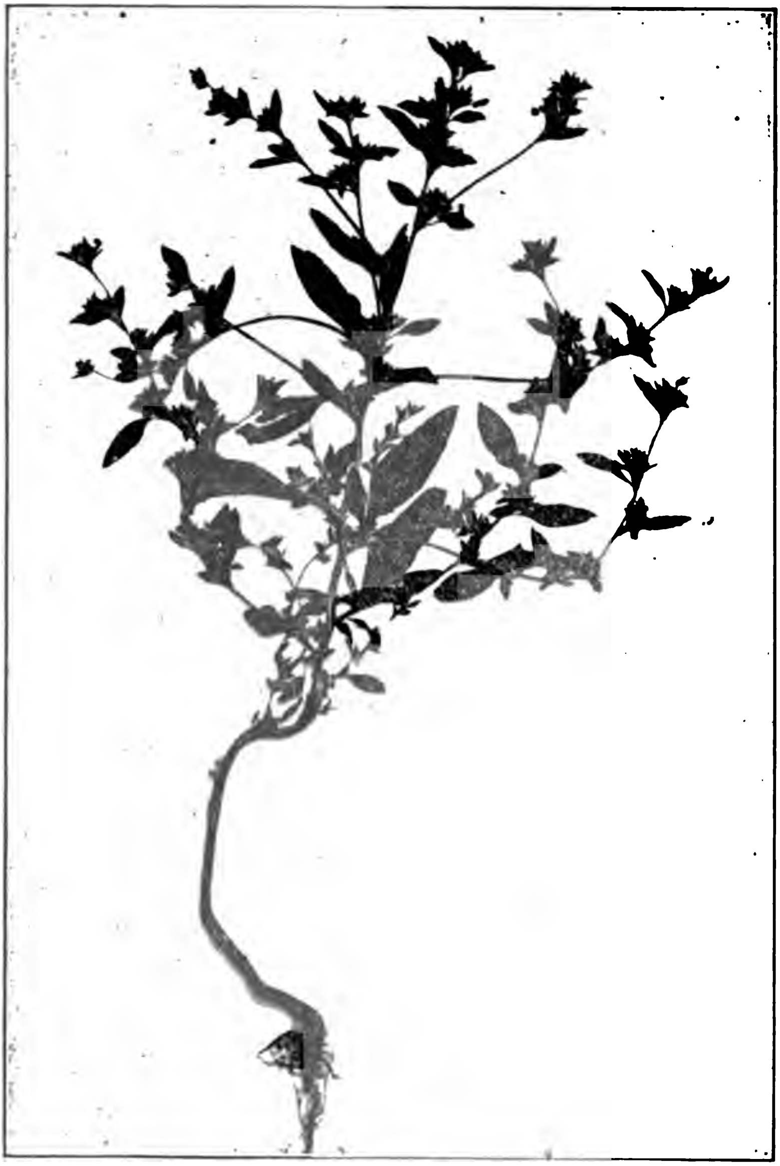

Plate I.—Russian Pigweed. (*Axyris amaranthoides*.)
From a photograph, about ⅔ natural size.

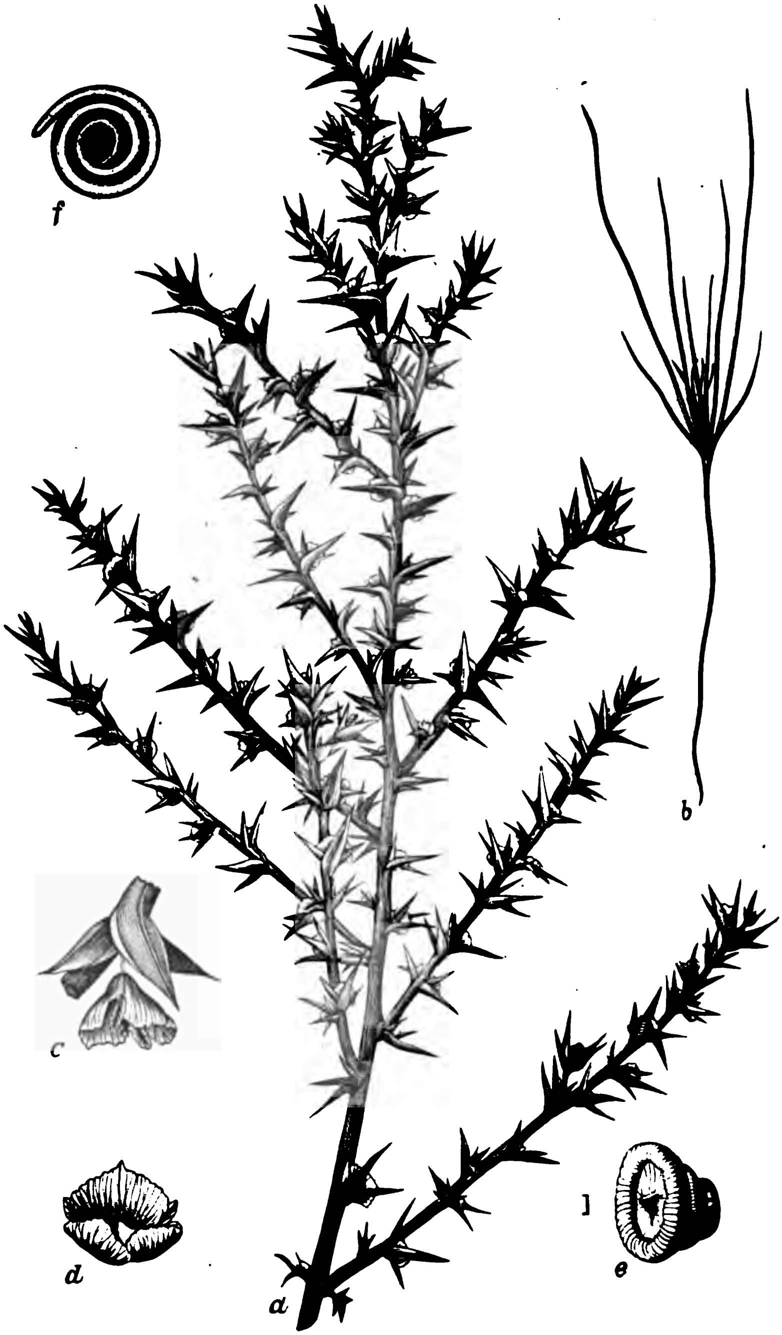

Plate II.—Russian Thistle. *a*. branch of mature plant, natural size; *b*, young seedling; *c*, flower and hairs; *d*, flower; *c* and *d* enlarged three times; *e*, seed, enlarged five times; *f*, embryo, enlarged. After L. H. Dewey, U. S. Department of Agriculture.

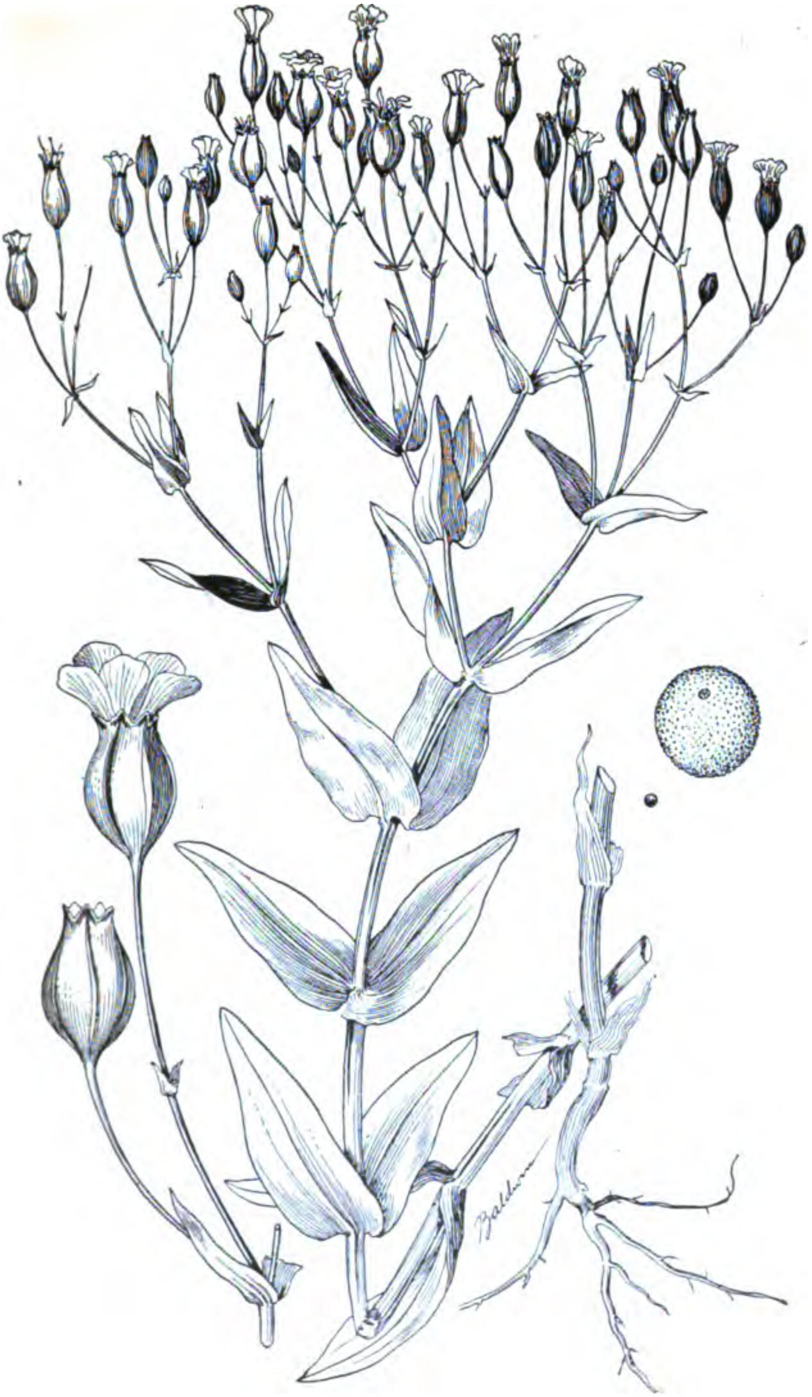

Plate III.—Pink Cockle. (*Vaccaria Vaccaria.*) Portion of plant with flowers: a flower and fruit, natural size: a seed natural size and one much enlarged. After Wilcox and Chestnut, U. S Department of Agriculture.

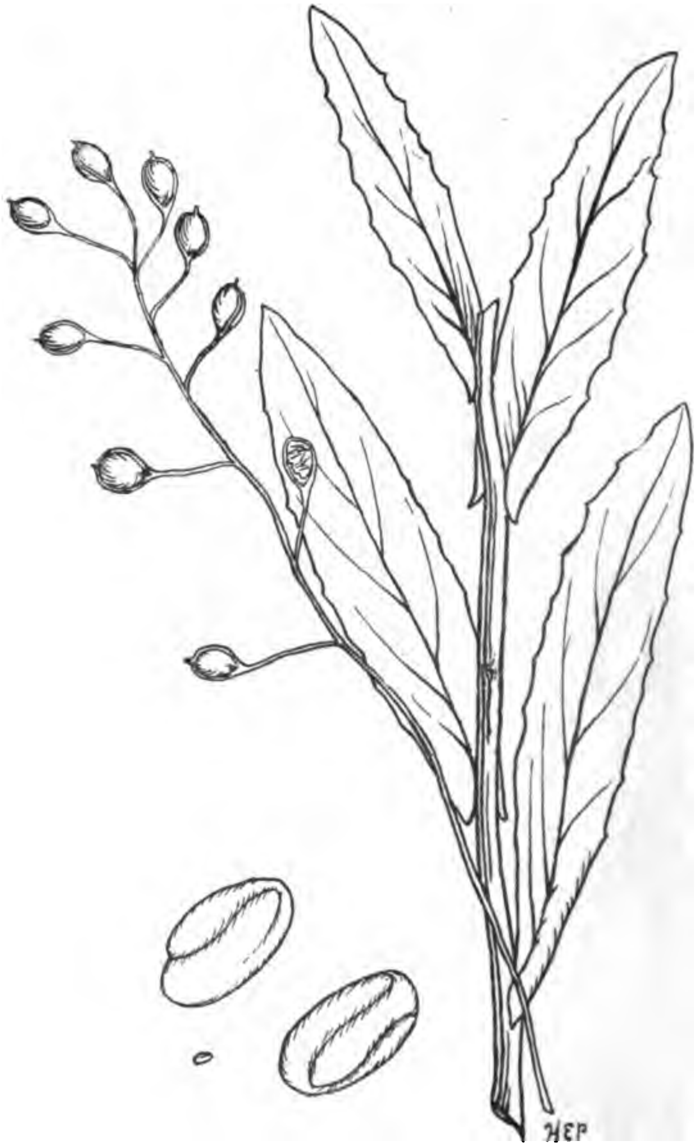

Plate IV.—False Flax. Portions of plant showing leaves and fruit (pods), both natural size; two views of a seed, enlarged.

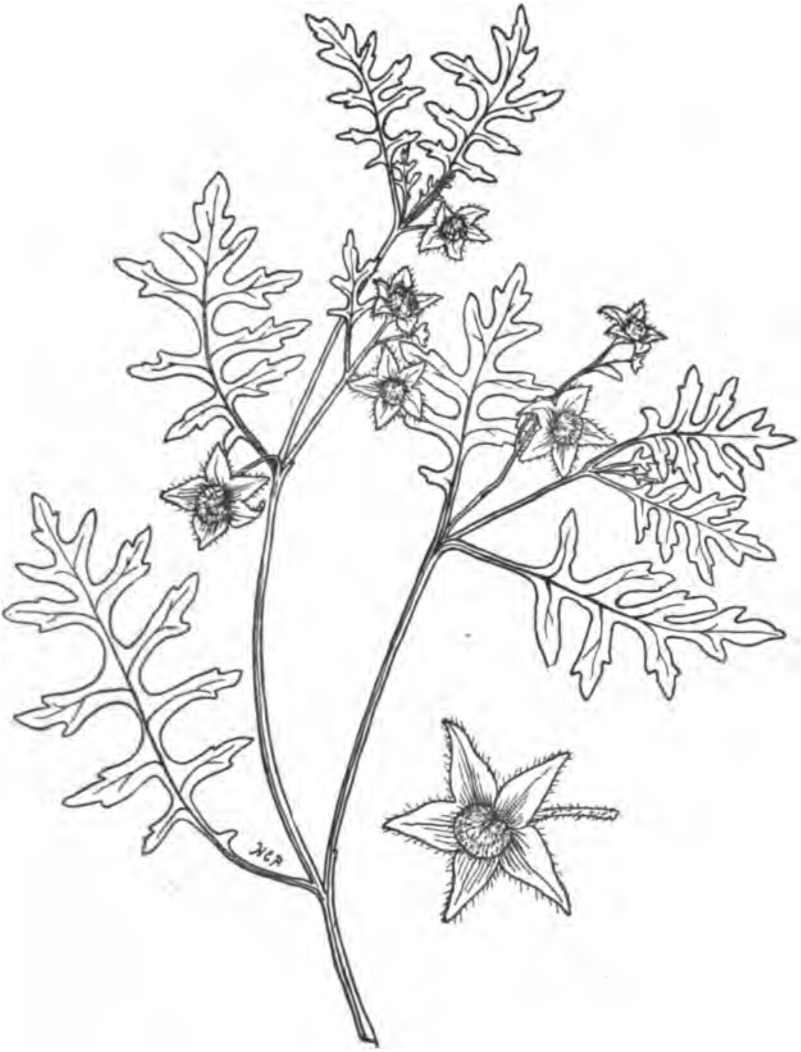

Plate V.—Nyctelea. (*Macrocalyx Nyctelea.*) Portion of plant three-fifths natural size; fruit with enlarged calyx, natural size.

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OWN A WEED SEED COLLECTION.

The Experiment Station has examined hundreds of samples of grain in the past few years, which was designed for seed. The vast majority of this grain contained too much foul weed seed to make it economical to sow. In many cases the farmer was ignorant of this condition. He did not know foul weed seeds were present, and even if he had, he would not have known the kinds. To enable the farmer to become acquainted with the different kinds of weed seed, the Botanical Department has prepared a weed seed collection, consisting of twenty-six kinds of the worst weed seeds of North Dakota. These seeds are in cork-stopped glass vials, labelled and enclosed in a neat partitioned box made to order for this purpose. The cost of this collection is $2.00, which only covers the cost of the vials, the box and the labor of collection. This collection, in the hands of an intelligent farmer, can easily pay for itself many times over in the course of one year. There is no profit on these, they are sold at cast. You are urged to buy a collection simply because it is to your advantage.

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MAR 11 1904

NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 57.

SOME FOOD PRODUCTS AND FOOD ADULTERATION.

By E. F. LADD.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
September, 1903.

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FOOD PRODUCTS AND THEIR ADULTERATION.

BY E. F. LADD, CHEMIST AND FOOD COMMISSIONER.*

During the past few months, or since the pure food law went into effect, July 1st, we have received and analyzed eight hundred and fifty one samples of food products. We have also passed upon the labeling of nearly one thousand additional samples. We have been in consultation with a large number of the manufacturers and jobbers, trying to aid all those who are making efforts to get their goods in shape to comply with the requirements of the North Dakota Pure Food Law. We believe, in this way, we have been able to accomplish much more, in the way of correcting existing evils, than could possibly be done by means of inspection of the food products offered for sale in the state, and the prosecution of those found violating the law. In the majority of cases the merchant is innocent of any intent of violating the law but has no means of knowing whether many of the goods which he handles are pure or adulterated.

The majority of the manufacturers and jobbers have shown a disposition to put their goods in such shape that there should be no violiation of the law, and frequently at our request have changed the label so that there should be no deception practiced.

In the North Dakota Pure Food Law, there seems to be laid down three cardinal principles, namely as follows:

1st. Harmful preservatives are prohibited from being used in food products.

2nd. The use of Coal Tar dyes is prohibited in all food proproducts and beverages offered for sale in North Dakota.

3rd. That all food products must be labeled true to name and no deception practiced in the wording so as to mislead the purchaser or consumer.

In our examination of food products we have kept these three points carefully in mind and have endeavored to so classify the products examined, that the public may know the true nature of the foods.

Many of the food products offered for sale have been in the past highly colored, and where goods were formerly, found colored, they may now be found showing but little color or only the color which is natural to them. When goods appear in their natural color, it is an indication of their purity and such goods should be given preference to those articfiially colored. Butter that is colored with coal tar dye is just as illegal in North Dakota as are jams, jellies and preserves when colored by the same means.

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*The analytical data for this bulletin was furnished jointly by, the author, Hugh McGuigan, Adele Shepperd, C. H. Kimberly and J. H. Norton.

In the following pages, we give a partial list of the food products that have been examined, reserving the matter of spices, meats, fish, syrups, molasses, soda fountain supplies, candies, etc. for consideration in a future bulletin.

CHEMICAL PRESERVATIVES IN FOODS.

In bulletin No. 53, issued by this department in 1902, the presence of formaldehyde was reported in various food products, and our statements that formaldehyde was being used as a food preservative aroused considerable discussion and brought with it considerable of criticism from others who had not found formaldehyde. Perhaps this was due to the fact that few have tested for formaldehyde in food products. To detect its presence with certainty requires, both skill and practice on the part of the analyst. One able chemist stated in a personal letter to me that undoubtedly formaldehyde was present in the products which he had examined and reported upon but stated that great skill was required in the detection of the formaldehyde with certainty and since he could not give his personal attention to the matter, he did not feel safe in entrusting the work to an assistant. Manufacturers who had been using formaldehyde previous to the publication of the bulletin have since largely discontinued its use, or at least we no longer are able to find it in goods from those establishments, but we do find the use of boracic acid and sulphites has become much more general.

In many cases wher formaldehyde has been found, the amount present is so small that we did not feel warranted in making a claim of its presence in view of the assertion that has been made by chemists of high repute. We have, however, found formaldehyde to be present in a sufficient number of cases that cannot be questioned so that we feel justified in further discussing the matter at this time.

We first mention a case where formaldehyde was found in a sample of condensed milk. In this can of milk the amount present was so large and the reaction so unmistakable that there could be no question of its being present. The manufacturers protested that they did not use formaldehyde or any other preservative in the preparation of their food products. Later tests made revealed the fact that formaldehyde was present in the milk as delivered at the factory. This placed the responsibility on the producers of the milk rather than on the condensers. It nevertheless shows that our ground was well taken.

A second case was that of mince meat where formaldehyde and borax or boracic acid were found in considerable quantities. Again the manufacturers protested that they used no preservatives whatever. They submitted a sample to an eastern chemist who confirmed our findings but stated that he believed that neither of these products were being added by the manufacturer. In other samples of the same goods we were unable to find formaldehyde but did repeatedly find borax or boracic acid. A careful investigation was undertaken to determine the source of these products. Samples of the several products used in the manufacture of the mince meats were secured from manufacturers in different parts of the country, and it was found in those cases where borax was present it could be traced directly to the raisins and in some instances to the currants as well. In some cases the raisins were so charged with borax that a single raisin would give a strong reaction for this product.

Mr. Merrill of the Merrill Soule Co., at Syracuse, N. Y. informed us that their raisins were all purchased from a firm in California. The W. H. Marvin Co., in reply to my inquiry, stated that they purchased their raisins from California. Mr. H. C. Gutchess informed me that the major part of their seedless raisins were purchased from Griffin & Skelly Co., San Francisco.

It has been claimed that this borax must have been put there by nature. This statement seems hardly warranted when we consider the amount that was present and that the principle part of the borax or boracic acid could be washed off from the surface of the unbroken raisin skins and in some instances its presence could be detected by the unaided eye.

The manufacturers of the sample of mince meat in which formadehyde was found informed me at the time the sample was made, about September 18th, 1902, that a reference to their records shows that the boiled cider which they were then using came from a different source than their regular supply and that the formaldehyde must have been present in this boiled cider.

On September 7th, we received a sample of peas, No. 764, which gave a good reaction for formaldehyde. We were unable to procure other samples of the same product but notified the canners, The Abert Landreth Co., of our find. To this notice the president of the company, Mr. A. C. Fraser, writes protesting that formaldehyde is not used in their factory. From this letter I quote the following "referring to the question of formaldehyde, if you have found reactions for this chemical in a can of Lakeside Little Gem Peas, manufactured by the Albert Landreth Co., I wish to say that it would be positive evidence that formaldehyde, or some other aldehyde giving a chemical reaction resembling it, does so form in a hermetically sealed can by natural processes, as I am perfectly familiar with all the steps taken in canning of peas by the Albert Landreth Co. and I can testify in the strongest manner possible that we use nothing but sugar, salt and clear spring water. This matter is of the utmost importance to the whole canning industry, and you will recognize, of course, the fact that there is danger of doing a great injustice to packers if the presence of formaldehyde in a can of vegetables leads you to reject not only this can but a whole lot, and imperil the reputation of the packer in so doing."

Under the exacting conditions in which this test was made, we are equally confident of the presence of formaldehyde. As to its source in the sample, for the present, we have no explanation to offer.

We then examined two samples of strawberries, the one put up by the Rochester Preserving Co., No. 701, and one bearing the label of Cuttice Bros. Co., Rochester, N. Y. the sample No. 741. The sample, No. 701, was found to contain formaldehyde. No. 741 was found to contain sulphites. The presence of these products seemed a little strange, especially the sulphites. We then had all reagents used in the method tested and a blank experiment made with negative results. We then had two chemists each work separately on the original samples and both secured positive results of the presence of formaldehyde and sulphites as in the first instance. We then notified the manufacturers and Curtice Bros. Co., replied as follows, "Replying to your notices, numbers 701 and 741 in reference to the samples of strawberries, the latter being marked 'Strawberry Preserves,' as having been found at Devils Lake, N. D., beg to state that your analysis regarding these is incorrect, as neither formaldehyde nor sulphites of any kind have been used in the preparation of our goods."

As stated above, we have an assertation that neither sulphites nor formaldehyde are used in the goods of this company. Nevertheless, under the most exacting conditions for making the test we have positive evidence of the presence of sulphites and formaldehyde in two separate samples. It may be added that other samples from the same house do not show either sulphites or formaldehyde.

I next call attention to a sample of Red Raspberries, No. 790, and a sample of Blackberries, No. 792, sent in by Winston, Harper, Fisher & Co., of Minneapolis, with the information that these goods were packed for them by the Geneva Preserving Co., Geneva, N. Y. Under the same exacting conditions for tests, No. 790 was found to contain sulphites and No. 792 gave the unmistakable test for the presence of formaldehyde. On notifying the canners of what we had found we received a reply from which we quote the following, "We will state positively that no sulphites nor formaldehyde nor any preservative of any kind whatsoever was used in canning the goods that we sold to Winston, Harper, Fisher & Co., or preparatory to canning. We do not use preservatives of any kind in canning or preparing our fruits. We do not make jams or anything of that kind and all of our fruits are put up in hermetically sealed tins.

"The fruits in question that we sold this year to Winston, Harper, Fisher & Co. consist of fruit just as it came from the producer, granulated sugar and water and absolutely nothing else was used. The only explanation that seems reasonable to us is that the cans were not of our packing. Of course the jobbers may buy of different packers and it is a very easy matter to get goods mixed when they all bear the jobbers label."

Dr. W. H. Jordan, in a personal letter, has the following to say regarding the work of Mr. Thorne, manager of the Geneva Preserving Co. "We know Mr. Thorne very well, as we have worked with him in studying the conditions involved in canning peas, and we believe him to be a thoroughly honest man. He says with great positiveness that there has not been a particle of sulphite or formaldehyde used in the preparation of these goods and I really believe he is telling the truth."

In this case there can be no question with regard to the presence of sulphites and we are equally positive of formaldehyde. If these products are not used by the manufacturers, they must be accounted for in some other way. It is very evident that sulphites cannot be formed by any changes which have taken place in the canned goods and in our experience we have no reason to believe under the conditions which exist in canned goods where they are in perfect condition, that formaldehyde would be formed. We have examined several samples of canned goods in various stages of fermentation and in not a single case could we find formaldehyde present, neither have we been able to induce such a change under like conditions of treatment.

The question then may fairly be asked, what is the source of the sulphites and formaldehyde found in the several samples which we have mentioned? If sulphites were not employed in the process of preparing or preserving the fruit and it did not occur in any of the products used in the process of canning, then the sulphites must have been in the fruit before they reached the factory. We believe the same statement may be made with regard to formaldehyde. Either they were added at the factory or they were added to some products before being brought to the factory. Instances might be multiplied, so that we do not believe that it can be attributed to any accident. Is it possible that the producers or shippers of the berries are using preservatives, in some instances, the active principle of which is sulphites and in others formaldehyde? It is a well known fact that the manufacturers of these preservatives are pushing their sales and advertising extensively. Future investigation must determine whether this supposition is correct.

We now sight another instance of the finding of formaldehyde in canned goods far in excess of anything we have previously reported. Winston, Harper, Fisher & Co. of Minneapolis sent us a sample of Extra Small Stringless Beans' put up for them by the Vodra Canning Co., of Two Rivers, Wis. These goods were to be prepared especially for the North Dakota trade and before accepting the same, the jobbers sent us a sample, No. 793, to determine whether they were put up in compliance with the state law. Our examination showed them to contain large quantities of formaldehyde and the tests were confirmed by the several methods usually employed for this work. A repetition of the work gave identically the same results. We then notified the jobbers of our findings and asked them if they could furnish us additional samples in order that we might have a more thorough investigation. The jobbers, Winston, Harper, Fisher & Co. sent us two sample cans of each of the following:

No. 807 ....White Wax Beans, University Brand.

No. 809 Extra Small Stringless Beans, Monogram Brand.
No. 810 ....Refuge Stringless Beans, Monogram Brand.
No. 812 ....String Beans, University Brand.
No. 813 ....Extra White Wax Beans, Monogram Brand.

With the exception of the last, No. 813, all were found to contain large quantities of formaldehyde. The amount of formaldehyde was so large that in the distillate in making some special tests, the fumes of the formaldehyde were given off so as to bring tears to the eyes of the chemist making the test and its odor was readily detected by other chemists fully fifteen feet away.

A sample of the distillate was sent to Commissioner McConnell, of Minnesota, with the request that he have their chemist examine the same for formaldehyde. In reply to our request, Prof. Hortvet reports as follows, "The sample submitted gives a very *strong reaction of formaldehyde.*

The Vodra Canning Co. made no reply to our notification of the finding of formaldehyde. Under date of Sept. 22nd, 1903, we received a letter from the Industrial Chemical Institute of Milwaukee from which I quote the following, "The Vodra Canning Co., of Two Rivers, Wis. submitted some cans of beans to be analyzed and tested for the presence of formaldehyde. The formaldehyde reaction was a distinct one. As you yourself have examined the same brand of beans and reported the same to contain a large amount of formaldehyde we beg to say that we cannot account for the presence of this substance...........In the canning process, there is no formaldehyde used, but a little ethyl alcohol. Is it not possible that by the process of preparing the liquid added to the beans, by the process of pasteurizing the cans, etc. the alcohol in such diluted form has been oxdized to aldehyde and that the presence of aldehyde must be explained in this way? We cannot find any other explanation for the presence of the substance in the cans, as there is no formaldehyde directly used in the factory..........

"We have been in business connection with this firm for years and cannot account for the presence of formaldehyde in the goods, except by supposing that the little quantity of alcohol used in putting up the beans had been oxidized to aldehyde."

All the samples of canned goods were apparently in a perfect state of preservation, and there was no indication that would lead one to believe that there had been any chemical change which could be found in our tests. The product was formaldehyde and not ethyl aldehyde as would be expected to be formed from ethyl alcohol, as clearly shown in our tests by chemists working independently. If wood spirits, methyl alcohol, was used in the process and by any means transformed into aldehyde, the offense must be considered even more serious.

As to how formaldehyde found its way into these canned goods, for the present we have nothing to say.

It may be stated, however, that among the goods examined and reported upon in Bulletin No. 53, No. 179 of page 129, the Blue Diamond Marrow Fat Peas put up by the E. J. Vodra Canning Co., Two Rivers, Wis., was found to contain both formaldehyde and salicylic acid. We believe that this is a further confirmation of the result of our work as published in Bulletin No. 53 and which met with considerable criticism from those who did not wish to believe that formaldehyde was being used in canned goods, preserves, etc. We believe that the use of formaldehyde, or of products which result in setting free of formaldehyde is much more general than is generally believed. From our geographical location we are not in a position to well investigate this problem, but believe that there is a good opportunity for the Department of Agriculture at Washington or for Mr. Duckwell, associated expert with H. J.. Heinz Co., who has not been the least sparing in criticism of our work to take up this important question.

If the canned goods of the E. J. Vodra Canning Co., presumably, from the pack of 1901 contained not only formaldehyde but salicylic acid in unmistakable quantities, it would seem not unlikely that they are at the present time still employing a preservative.

We believe that we have now demonstrated that we were justified in reporting the presence of formaldehyde as shown in Bulletin No. 53 and those who have had their doubts can now find their proof in the statement of other disinterested chemists working independently.

It may be stated in closing that we are withholding the data in a number of instances where there might be a possibility of doubt in the minds of those who are not wholly familiar with the technique of the work.

PRESERVES, JAMS, JELLIES, ETC.

Lab. No. 40. (Legal.)
Brand, Gleason's Grape Juice.
Producer and Jobber, Gleason Grape Juice Co., Ripley, N. Y.
Retailer, Fout & Porterfield, Fargo.

Lab. No. 68. (Legal.)
Brand, Cal. Yellow Crawford Peaches University.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Retailer, Berg. Bros., Cooperstown.

Lab. No. 82. (Legal.)
Brand, Pure Blackberry Jam, Dinner Party.
Producer and Jobber, Orchard Park Canning Co., Orchard Park, New York.
Retailer, Nash Bros., Grand Forks.

Lab. No. 113. (Legal.)
Brand, Strawberry Jam, Our Favorite.
Producer and Jobber, Farnham Canning Co., Erie, N. Y.
Retailer, Mr. Grant, Fargo.

Lab. No. 117. (Passed.)
Brand, Raspberry Preserves, Griffin's Extra.
Producer and Jobber, California Fruit Canners Association.
Retailer, Mr. Grant, Fargo.

Lab. No. 139. (Passed.)
Brand, Strawberry Preserves, Purity.
Producer and Jobber, E. G. Daily Co., Detroit, Mich.
Retailer, Anthony Kelly Co., Minneapolis.

Lab. No. 217.
Brand, Strawberry Preserves, Purity.
Producer and Jobber, E. G. Dailly & Co., Detroit, Mich.
Retailer, Anthony, Kelly & Co., Minneapolis.

Lab. No. 243. (Legal.)
Brand, Strawberry Preserves, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 244. (Legal.)
Brand, Red Currant Jelly, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 252. (Legal.)

Brand, Strawberries, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 253. (Legal.)

Brand, Blackberries, Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 254. (Legal.)

Brand, Red Cherries, Jack Rose.
Producer and Jobber, Fleming & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 255. (Legal.)

Brand, Grated Pineapple, Gold Seal.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 256. (Passed.)

Brand, Raspberries, Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 259. (Legal.)

Brand, Strawberries, Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 262. (Legal.)

Brand, Grated Pineapple, Florida.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 263. (Legal.)

Brand, Choice Rhubarb, Aurora.
Producer and Jobber, Geneva Preserving Co., Geneva, N. Y.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 264. (Passed.)

Brand, Pie Peaches, Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 266. (Legal.)

Brand, Bartlett Pears, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 267. (Passed.)

Brand, Red Pitted Cherries, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 270. (Legal.)

Brand, Sliced Peaches for Cream, Bengal.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 271. (Legal.)

Brand, Bartlett Pears, Vertibull.
Producer and Jobber, H. F. Hemingway & Co., Baltimore, Md.

Lab. No. 273. (Passed.)

Brand, Fresh Peaches, 1st Quality.
Producer and Jobber, P. Wheeler & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 274. (Passed.)

Brand, Apricots, Amazon.
Producer and Jobber, Haywards Canning Co., Haywards Cal.

Lab. No.275. (Legal.)

Brand, Crawford Peaches, Hesperian.
Producer and Jobber, Hunt Bros. Co., Haywards, Cal.

Lab. No. 282. (Legal.)

Brand, Gooseberries, Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 286. (Legal.)

Brand, White Cherries, Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 288. (Legal.)

Brand, Red Raspberries, preserves, America.
Producer and Jobber, Kidwell Bros. & Co., Baltimore, Md.

Lab. No. 290. (Legal.)
Brand, Gooseberries, Bengal.
Producer and Jobber, Griggs, Cooper & Co.

Lab. No. 295. (Legal.)
Brand, Blueberries, Eagle.
Producer and Jobber, A. & R. Loggie, Loggiville, N. B. Canada
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 296. (Legal.)
Brand, Preserved Strawberries, Bengal.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 300. (Passed.)
Brand, Strawberries, Canned.
Producer and Jobber, Geo. R. Newell, Minneapolis.

Lab. No. 304. (Legal.)
Brand, Blueberries, Eagle.
Producer and Jobber, A. & R. Loggie, Loggieville, N. B., Canada
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 313. (Passed.)
Brand, White Cherries, Ox Heart, Honey Dew.
Producer and Jobber, Erie Preserving Co., Buffalo, N. Y.

Lab. No. 317. (Legal.)
Brand, Red Raspberries, Honey Dew.
Producer and Jobber, Erie Preserving Co., Buffalo, N. Y.

Lab. No. 318. (Passed.)
Brand, Red Raspberry Jam, Honey Dew.
Producer and Jobber, Erie Preserving Co., Buffalo, N. Y.

Lab. No. 319. (Passed.)
Brand, Pure Strawberry Jam, Honey Dew.
Producer and Jobber, Erie Preserving Co., Fenton, N. Y.

Lab. No. 320. (Passed?)
Brand, Black Raspberry Jam, Honey Dew.
Producer and Jobber, Erie Preserving Co.

Lab. No. 326. (Legal.)
Brand, Raspberry ,Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 327. (Legal.)

Brand, Blue Berries, Eagle.
Producer and Jobber, A. & R. Loggie, Loggieville, N. B., Canada.
Retailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 335. (Legal.)

Extra Strawberries, Flour City.
Producer and Jobber, Curtice Bros, Rochester, N. Y.
Retailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 338. (Passed.)

Brand, Gooseberries, Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 340. (Legal.)

Brand, Blackberries, Extra Standard.
Producer and Jobber, Gibb's Preserving Co., Baltimore, Md.
Retailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 343. (Passed.)

Brand, Gooseberries, Ribbon.
Producer and Jobber, Geneva, N. Y. Co. not given.

Lab. No. 345. (Legal.)

Brand, Strawberries, Challenge.
Producer and Jobber, H. S. Langfair & Co., Baltimore, Md.

Lab. No. 350. (Legal.)

Brand, Preserved Red Raspberries, Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 353. (Legal.)

Brand, Sliced Pineapple, No. 5.
Producer and Jobber, Foley Bros. & Kelly, St. Paul.

Lab. No. 354. (Legal.)

Brand, Grated Pineapple, No. 6.
Producer and Jobber, Foley Bros. & Kelly, St. Paul.

Lab. No. 362. (Legal.)

Brand, Black Raspberries, No. 2.
Producer and Jobber, Foley Bros. & Kelly, St. Paul.

Lab. No. 363. (Legal.)
Brand, Preserved Blackberries, No. 3.
Producer and Jobber, Foley Bros. & Kelly, St. Paul.

Lab. No. 364. (Legal.)
Brand, Strawberries, No. 1.
Producer and Jobber, Foley Bros. & Kelly, St. Paul.

Lab. No. 367 (Legal.)
Brand, Gooseberries Preserved, No. 4.
Producer and Jobber, Foley Bros. & Kelly, St. Paul.

Lab. No. 381. (Passed.)
Brand, Blackberries, Victory.
Producer and Jobber, John Boyle Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul, Minn.

Lab. No. 382. (Legal.)
Brand, Strawberries, Victory.
Producer and Jobber, John Boyle Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul, Minn.

Lab. No. 383. (Legal.)
Brand, Grated Pineapple, Florida.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 384. (Legal.)
Brand, Sliced Pineapple, Florida.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 385. (Legal.)
Brand, Extra Pineapple, Oval.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 386. (Legal.)
Brand, Grated Pineapple, Gold Seal.
Producer and Jobber, A. Booth & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 387. (Legal.)
Brand, Blueberries, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 476. (Legal.)

Brand, Preserved Strawberries, University.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Retailer, M. Grange, Sheldon.

Lab. No. 490. (Legal.)

Brand, Preserved Pitted Cherries, Millionaire's Club.
Producer and Jobber, Fenton Bros. Co., Fenton, N. Y.
Retailer, H. V. Hicks & Son, Oakes.

Lab. No. 491. (Legal.)

Brand, Red Raspberries, Gertfield.
Producer and Jobber, North Collin's Preserving Co., North Collins, New York.
Retailer, H. V. Hicks & Son, Oakes.

Lab. No. 500. (Legal.)

Brand, Strawberries, Jewett's High Grade.
Producer and Jobber, Jewett Bros., Aberdeen, S. D.
Retailer, Cunningham & Lawrence, La Moure.

Lab. No. 510. (Legal.)

Brand, Preserved Strawberries, University.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Retailer, Hurley Bros., Forman.

Lab. No. 554. (Questionable.)

Brand, Pure Strawberry Jelly, Belmont.
Producer and Jobber, Chicago Concentrating Co., Chicago, Ill.
Retailer, Wright, Clarkson Mercantile Co., Duluth, Minn.

Lab. No. 581. (Legal.)

Brand, Strawberry Table Preserves.
Producer and Jobber, Curtice Bros. Co., Rochester, N. Y.
Retailer, M. W. Hansen & Co., Grand Forks.

Lab. No. 612. (Legal.)

Brand, Strawberries, Boyer's.
Producer and Jobber, W. W. Boyer & Co., Baltimore, Md.
Retailer, J. O. Hansen, Churchs Ferry.

Lab. No. 616.

Brand, Cherry Preserves, Heinz's.
Producer and Jobber, H. J. Heinz Co., Pittsburg, Pa.
Retailer, C. T. Studness, Churches Ferry.

Lab No. 655. (Legal.)

Brand, Strawberry Preserves, Fort Snelling.
Producer and Jobber, Foley Bros. & Kelly, St. Paul.
Retailer, J. La Moure & Co., Neche.

Lab. No. 755. (Legal.)

Brand, Black Raspberry, Navy.
Brand, Cobb Preserving Co., Fariport, N. Y.
Retailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 760. (Legal.'

Brand, Strawberry Preserves, Peerless.
Producer and Jobber, C. H. Pearson Packing Co., Baltimore, Md.
Retailer, Fargo Mercantile Co., Fargo.

Lab. No. 762. (Legal.)

Brand, Red Raspberry Preserves, Peerless.
Producer and Jobber, C. H. Pearson Packing Co., Baltimore, Md.
Retailer, Fargo Mercantile Co., Fargo.

Lab. No. 763. (Legal.)

Brand, Blueberries, Peerless.
Producer and Jobber, C. H. Pearson Packing Co., Baltimore, Md.
Retailer, Fargo Mercantile Co., Fargo.

Lab. No. 791. (Legal.)

Brand, Black Raspberries, Monogram.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.

PRESERVES, JAMS, JELLIES, ETC., ILLEGAL.

Lab. No. 41.
Brand, Welch's Grape Juice.
Producer and Jobber, Welch Grape Juice Co., Westfield, N. Y.
Retailer, Christianson's Drug Store, Fargo.
Preservative, Acid Salicylic. Color, Natural.

Lab. No. 79.
Brand, Preserved Strawberries, Monogram.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Color, Coal Tar Dye.

Lab. No. 80.
Brand, Preserved Strawberries, University.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Preservative, Saccharin. Color, Coal Tar Dye.

Lab. No. 137.
Brand, Farren's Strawberries, Shield.
Producer and Jobber, J. S. Farren & Co., Baltimore, Md.
Retailer, Winston, Harper, Fisher & Co., Minneapolis.
Preservative, Saccharin.

Lab. No. 199.
Brand, Strawberries, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.
Preservative, Benzoic acid or Benzoate of Soda.

Lab. No. 200.
Brand, Preserved Strawberries, Bengal.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.
Preservative, Benzoic acid. Color, Added Color.

Lab. No. 241.
Brand, Preserved Strawberries, Bengal.
Producer and Jobber, Griggs, Cooper & Co., St. Paul, Minn.
Is not strawberry and contains starch paste.

Lab. No. 242. (Illegal.)
Brand, Strawberry Preserves, Victor.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.
Not pure strawberry fruit.

Lab. No. 312.
Brand, Red Cherry Preserves, Honey Dew.
Producer and Jobber, Erie Preserving Co., Buffalo, N. Y.
Color, Coal Tar Dye.

Lab. No.314.

Brand, Preserved Strawberries, Honey Dew.
Producer and Jobber, Erie Preserving Co., Buffalo, N. Y.
Color, Coal Tar Dye.

Lab. No.372.

Brand, Strawberries, Newell's Extra.
Producer and Jobber, Geo. R. Newell, Minneapolis.
Preservative, Salicylic Acid.

Lab. No. 436.

Brand, Canned Strawberries.
Producer and Jobber, Geo. R. Newell, Minneapolis.
Color, Coal Tar Dye.

Lab. No. 456.

Brand, Preserved Strawberries, U. S.
Producer and Jobber, U. S. Canning Co., Fredonia, N. Y.
Retailer, Joseph Goodman, Sheldon.
Preservative, Acid Salicylic.

Lab. No. 482.

Brand, Red Raspberry Jam, Honey Dew.
Producer and Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, Ramharter Bros., Oakes.
Color, Coal Tar Dye.

Lab. No. 555.

Brand, Raspberry Preserves, Golf Club.
Producer and Jobber, Chicago Concentrating Co., Chicago, Ill.
Retailer, Wright, Clarkson Mercantile Co., Duluth, Minn.
Preservative, Acid Benzoic. Color, Cochineal.

Lab. No. 556.

Brand, Raspberry, Belmont.
Producer and Jobber, Chicago Concentrating Co., Chicago, Ill.
Retaierl, Wright, Clarkson Mercantile Co., Duluth, Minn.
Preservative, Acid Benzoic. Color, Coal Tar Dye.

Lab. No. 573.

Brand, California Fruit Preserver.
Producer, Unknown.
Sent in by W. B. Douglas, Fargo.
Preservative, Acid Salicylic.

Lab. No. 574.

Brand, Raspberry Jelly, Miss William's Pure Home.
Made in Desmoines, Iowa.
Retailer, W. F. Perry, Grand Forks.
Preservative, Acid Salicylic. Color Vegetable Color.

Lab. No. 582.

Brand, Strawberry Jam, Fresh Fruit, Extra Quality.
Producer and Jobber, Curtice Bros. Co., Rochester, N. Y.
Retailer, M. W. Hansen, Grand Forks.
Preservative, Benzoic Acid.

Lab. No. 615.

Brand, Strawberry Preserves, Pure Food.
Producer and Jobber, Pure Food Preserving Co., Buffalo, N. Y.
Retailer, C. T. Studness, Churches Ferry.
Color, Coal Tar Dye.

Lab. No. 626.

Brand, Red Raspberry Preserves, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.
Retailer, P. A. Jorgenson, Grafton.
Preservative, Benzoic Acid. Color, Coal Tar Dye.

Lab. No. 633.

Brand, Currant Jelly, Heinz.
Producer and Jobber, H. J. Heinz Co., Pittsburg, Pa.
Retailer, H. G.| Sprague, Grafton.
Preservative, Sulphites, Benzoic Acid.

Lab. No. 701.

Brand, Strawberries, Monroe.
Producer and Jobber, Rochester Preserving Co., Rochester, N. Y.
Retailer, Devils Lake Co-operative Association.
Preservative, Formaldehyde.

Lab.No. 712.

Brand, Grape Jam, Eagle.
Producer and Jobber, Anderson Preserving Co., Camden, N. J.
Retailer, P. de Fiore, Devils Lake.
Preservative, Sulphite. Color, Coal Tar Dye.

CORN AND SUCCOTASH, LEGAL.

Lab. No. 136.
Brand, Little Indian.
Producer and Jobber, Frank T. Stare & Co., Waukesha, Wis.
Retailer, Winston, Harper, Fisher & Co., Minneapolis.

Lab.No. 138.
Brand, Margueret Sweet.
Producer and Jobber, Gilman Canning Co., Gilman, Iowa.
Retailer, Winston, Harper, Fisher & Co., Minneapolis.

Lab. No. 269.
Brand, Home Brand Succotash.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 289.
Brand, Honeymoon.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab.No. 292.
Brand, Lilac.
Producer and Jobber, Kelley Canning Co., Waverly, Iowa.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 293.
Brand, Red Oak.
Producer and Jobber, Camden Packing Co., Camden, N. Y.

Lab. No.481.
Brand, Jewett's High Grade.
Producer and Jobber, Jewett Bros., Aberdeen, S. D.
Retailer, Ramharter Bros, Oakes.

Lab. No. 511.
Brand, Gilman's Early Crosby.
Producer and Jobber, Gilman Canning Co., Gilman, Iowa.
Retailer, Hurly Bros., Forman.
Cost, .10.

Lab. No. 558.
Brand, Winsted.
Producer and Jobber, Winsted Canning Co., Auburn, N. Y.
Retailer, Mr. Clark, Larimore.
Cost, 12½.

Lab. No. 579.

Brand, Lincoln.
Producer and Jobber, Lowell Canning Co., Lowell, N. Y.
Retailer, Salstad & Booker, Grand Forks.
Cost, 12 1-2.

Lab. No. 610.

Brand, Succotash, Lake Side.
Producer and Jobber, Snow Flake Canning Co., Brunswick, Me.
Retailer, S. S. Moen, Churches Ferry.
Cost, .15.

Leb. No. 702.

Brand, Napoleon.
Producer and Jobber, Waterloo Canning Co., Waterloo, Iowa.
Retailer, Devils Lake Co-operative Association.

Lab.No. 717.

Brand, Early Sweet Corn.
Producer and Jobber, Curtice Bros. Co., Rochester, N. Y.
Retailer, P. de Fiore, Devils Lake.
Cost, .15.

Lab. No. 740.

Brand, Bengal.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.
Retailer, F. W. Manns & Son, Devils Lake.

Lab. No. 742.

Brand, Extra Fine Empress.
Producer and Jobber, Baxter Bros., Brunswick, Maine.
Retailer, Monson Bros. & Co., Brocket.
Cost, .15.

Lab. No. 799.

Brand, Winnebago.
Producer and Jobber, Lake Mills Canning Co., Lake Mills, Iowa.
Retailer, Nash Bros., Grand Forks.

Lab. No. 808.

Brand, University.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.

Lab. No. 822.

Brand, Sugar Corn,
Producer and Jobber, Lake Mills Canning Co., Lake Mills, Iowa.
Retailer, Nash Bros., Grand Forks.

CORN AND SUCCOTASH, ILLEGAL.

Lab. No. 342.

Brand, Extra Choice, Canton.
Producers and Jobbers, Canton Canning Co., Canton, Mo.
Retailers, Foley Bros. & Kelly., St. Paul.
Preservative, Sulphites.

Lab. No. 348.

Brand, Rockwell.
Producers and Jobbers, Rockwell City Canning Co., Rockwell, Ia.
Retailers, Foley Bros.& Kelly, St. Paul.
Preservative, Sulphites.

Lab. No.435.

Producers and Jobbers, Anthony Kelly & Co., Minneapolis.
Preservative, Sulphites.

Lab. No. 495.

Brand, Faribault Extra Old Colony.
Producers and Jobbers, Faribault Canning Co., Faribault, Minn.
Retailers, Klein & Sutmar, Oakes.
Preservative, Sulphites.

Lab. No. 545.

Brand, Waldorf.
Producers and Jobbers, Metropolitan Canning Co., Rome, N. Y.
Retailers, Wm. O'Hara, Bismarck.
Preservatives, Sulphites, Saccharin.

Lab. No. 611.

Brand, Newark Sweet Corn.
Producers and Jobbers, Wayne County Preserving Co,. Newark, N. Y.
Retailer, S. S. Moen, Churches Ferry.
Preservative, Sulphites.

Lab. No. 620.

Brand, Glenwood.
Producers and Jobbers, New Glenwood Canning Co., Glenwood, Ia.
Retailers, Chas. Moore & Son, Grafton, N. D.
Preservative, Sulphite, Saccharin.

Lab. No. 652.

Brand, Standard Quality Carol.
Producers and Jobbers, Geo. R. Newell & Co., Minenapolis.
Retailers, W. Crawford & Son, Neche, N. D.
Preservative, Sulphites.

Lab. No. 656.

Brand, Plymouth.
Producers and Jobbers, Bangor Packing Co., Bangor, Mo.
Retailers, J. La Moure & Co., Neche, N. D.
Preservative, Sulphites.

Lab. No. 716.

Brand, Succotash, Log Cabin.
Producers and Jobbers, F. & I. J. White, Blossvale, N. Y.
Retailers, P. de Fiore, Devils Lake.
Preservative, Sulphites.

Lab. No. 765A.

Producers and Jobbers, Burt Olney Canning Co., Oneida, N. Y.
Preservative, Sulphites.

Lab. No. 766B.

Burt Olney Canning Co., Oneida, N. Y.
Preservative, Sulphites, Saccharin.

PEAS AND BEANS, LEGAL.

Lab. No. 114.

Brand, Monitor.
Producer and Jobber, Lang Canning Co., Eau Claire, Wis.
Retailer, Mr. Grant, Fargo.

Lab. No. 208.

Brand, Barrow.
Producer and Jobber, N. Wis. Canning Co., Barrow, Wis.
Retailer, S. C. Tooker & Co., Minenapolis.

Lab. No. 209.

Brand, Barrow.
Producer and Jobber, N. Wis. Canning Co., Barrow, Wis.
Retailer, S. C. Tooker & Co., Minneapolis.

Lab. No. 210.

Brand, Marrow Fat Barrow.
Producer and Jobber, N. Wis. Canning Co., Barrow, Wis.
Retailer, S. C. Tooker & Co., Minneapolis.

Lab. No. 211.

Brand, Standard Barrow.
Producer and Jobber, N. Wis. Canning Co., Barrow, Wis.
Retailer, S. C. Tooker & Co., Minneapolis.

Lab. No. 279.

Brand, Reynolds Sweet Early June Peas.
Producer and Jobber, Reynolds Preserving Co., Sturgeons Bay, Wis.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 281.

Brand, Bengal.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 283.

Brand, Bengal.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 287.

Brand, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.

Lab. No. 315.

Brand, Honey Dew.
Producer and Jobber, Erie Preserving Co., Buffalo, N. Y.

Lab. No. 316.

Brand, Honey Dew.
Producer and Jobber, Erie Preserving Co., Buffalo, N. Y.

Lab. No. 328.

Brand, Barrow.
Producer and Jobber, N. Wis. Canning Co., Barrow, Wis.
Retailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 336.

Brand, Early June.
Producer and Jobber, Fort Atkinson Canning Co., Fort Atkinson, Wisconsin.

Lab. No. 346.

Brand, Little Quaker.
Producer and Jobber, W. R. Roach & Co., Hart, Mich.
Reailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 728A.

Brand, White Horse, Selected.
Producer and Jobber, Reid, Murdoch & Co., Chicago, Iill.
Retailer, A. D. Sprague, Devils Lake.

Lab. No. 739.

Brand, Sweet Garden.
Producer and Jobber, Curtice Bros. Co., Rochester, N. Y.
Retailer, F. W. Manns & Son, Devils Lake.

Lab. No. 777.

Brand, C.
Producer and Jobber, Burt Olney Canning Co., Oneida, N. Y.

Lab. No. 811.

Brand, Monogram.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.

Lab. No. 813.

Brand, Beans, White Wax Monogram.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.

PEAS AND BEANS, ILLEGAL.

Lab. No. 115.

Brand, Valley.
Producer and Jobber, Valley Canning Co., Eau Claire, Wis.
Retailer, Mr. Grant, Fargo.
Preservative, Borax or Boracic Acid.

Lab. No. 764.

Brand, Lakeside.
Producer and Jobber, Albert Landreth Co., Manitowac, Wis.
Retailer, Geo. H. Wilder, Grand Forks.
Preservative, Gives reaction for formaldehyde.

Lab. No. 778.

Brand, D.
Producer and Jobber, Burt Olney Canning Co., Oneida, N. Y.
Preservative, Saccharin.

*Lab. No. 793.

Beans, Monogram.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Preservative, Formaldehyde, Large Amount.

*Lab. No. 807.

Brand, Beans, University.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Preservative, Formaldehyde, Large Amount.

*Lab. No. 809.

Brand, Beans, Small Stringless, Monogram.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Preservative, Formaldehyde, Large Amount.

*Lab. No. 810.

Brand, Beans, Refuge Stringless, Monogram.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Preservative, Formaldehyde, Large Amount.

*Lab. No. 812.

Brand, String Beans, University.
Producer and Jobber, Winston, Harper, Fisher & Co., Minneapolis.
Preservative, Formaldehyde, Large Amount.

*In justice to the jobbers, Winston, Harper, Fisher & Co., it should be said the goods were put up for them by the Vodra Canning Co., Wisconsin, to be accepted if they were found free from preservatives and complied with the North Dakota Pure Food Law. The samples were sent by them to us to see if the packers were complying with the law.

TOMATOES—CANNED.

Legal or Passed.

Lab. No. 260.
Brand, Rose Hill.
Producer and Jobber, Chas. Webster, East New Market, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 277.
Brand, Maryland Beauties.
Producer and Jobber, R. E. Roberts & Co., Baltimore, Md.
Retailer, Griggs, Cooper & Co., St. Paul.

Lab. No. 334.
Brand, Great Western.
Producer and Jobber, Great Western Canning Co., Wabash, Ind.
Retailer, Foley Bros. & Kelly, St. Paul.

Lab. No. 728.
Brand, Electric.
Producer and Jobber, Elkton Canning Co., Elkton, Md.
Retailer, A. D. Sprague, Devils Lake.
A very inferior product.

Lab. No. 788.
Brand, Golden Crown.
Producer and Jobber, Aughinbaugh Canning Co., Baltimore, Md.
Retailer, Nash Bros., Grand Forks.

Lab. No. 789.
Brand, Standard Packing 1903.
Producer and Jobber, Strausberg, Steckel. Hewett & Co., Aberdeen, Maryland.
Retailer, Nash Bros., Grand Forks.

Lab. No. 800.
Brand, Pride of Virginia.
Producer and Jobber L. W. Courtney & Son, Mundy's Point, Md.
Retailer, Nash Bros., Grand Forks.

Lab. No. 711.
Brand, Blue Hen Chicken.
Producer and Jobber, J. S. Reynolds & Co., Frederica, Del.
Retailer, Nimmo Bros., Devils Lake.
(Passed.)

TOMATOES, CANNED, ILLEGAL.

Lab. No. 189.
Brand, Blue Hen Chicken.
Producer and Jobber, J. S. Reynolds & Co., Frederica, Del.
Retailer, Jerse Norton, Duluth.
Preservative, Borax.

Lab. No. 190.
Brand, Blue Hen Chicken.
Producer and Jobber, J. S. Reynolds & Co., Frederica, Del.
Retailer, Jerse Norton, Duluth.
Preservative, Borax.

I have frequently stated that cans of tomatoes had been found which were filled with green tomatoes and then colored with coal tar dyes to give them the appearance of ripe tomatoes. I have maintained that such practice was disreptuable and that the sale of this class of goods should be prohibited. Jobbers and packers alike have protested that this was not true and that no reliable house would for a moment tolerate such a practice.

As bearing out my contention, I quote from Tho American Grocer of September 30th, from an article entitled Outrageous Packing Methods, the following:—"In one of the prominent factories of Baltimore, I saw tomatoes being put up in cans that, from a packer's standpoint, I would say were unfit for use. They were sour, green, knotty and positively unmerchantable in any decent respectable market. Not only were they packing that sort of raw stock in cans, but were working the pulp machine overtime, using up the skins and cores, and by the addition of water sought to raise the general average per ton. The green stock necessitated a free use of "paint" or coloring matter, which I regret to say, was being freely used in factories in Delaware and Maryland. The average of these cans of unmerchantable tomatoes, I was told, was as high as 16 to 18 cans per bushel, whereas no honest packer can get out of a bushel more than about twelve cans. As you can readily understand, the difference between 12 and 18 cans is made up of pulp and water a filler solely."

In conclusion we may say that we have examined one sample of canned tomatoes which should properly be classed as "swill," No. 728 and when the contents of the can were poured upon cheese cloth, 88.36 per cent drained through leaving but 11.64 per cent of wet tomatoes. Another lot, No. 711, treated in like matter gave 87 per cent of filtrate and 13 per cent of wet solids.

This "swill" like product was put up in the states of Maryland and Delaware. If the present food law does not make illegal the sending into North Dakota such "swill" to be sold as food products then the same should be amended. The matter will probably be brought to the attention of the courts in the near future. The cases sighted are by no means the worst examples that might be pointed out. The same statement may well be made regarding some of the canned fruits and berries now being shipped to this state.

It is our intention to make a complete analysis of this class of products and publish the results in a future report.

TOMATO CATSUPS—ILLEGAL

Lab. No. 35.
Producer and Jobber, Unknown.
Retailer, Lonbakker, Brocket.
Color, Coal Tar Dye.

Lab. No. 36.
Producer and Jobber, Unknown.
Retailer, Lonbakker, Brocket.
Color, Coal Tar Dye.

Lab. No.71.
Brand, Van Camp's Tomato.
Producer and Jobber, Van Camp Packing Co., Indianapolis, Ind.
Retailer, Berg Bros., Cooperstown.
Cost, .15.
Color, Coal Tar Dye.

Lab. No. 181.
Brand, Libby's Tomato.
Producer and Jobber, Libby, McNeill & Libby, Chicago, Ill.
Color, Coal Tar Dye.

Lab. No. 212.
Brand, Snider's Home Made.
Producer and Jobber, T. A. Snider Preserv. Co., Cincinnati, Ohio.
Retailer, Winston, Harper, Fisher & Co., Minneapolis.
Color, Coal Tar Dye.

Lab. No. 213.
Brand, Tomato.
Producer and Jobber, National Pure Food Co., Cincinnati, Ohio.
Retailer, Winston, Harper, Fisher & Co., Minneapolis.
Color, Coal Tar Dye.

Lab. No. 221.
Brand, Monarch.
Producer and Jobber, Reid, Murdoch & Co., Chicago, Ill.
Retailer, C. J. Calmer, Fargo.
Color, Coal Tar Dye.

Lab. No. 233.
Brand, Home.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.
Color, Coal Tar Dye.

Lab. No. 234.
Brand, Colonial.
Producer and Jobber, Griggs, Cooper & Co., St. Paul.
Color, Coal Tar Dye.

Lab. No. 355.
Brand, No. 16.
Producer and Jobber, Foley Bros. & Kelly, St. Paul.
Color, Coal Tar Dye.

Lab. No. 356.
Brand, No. 17.
Producer and Jobber, Foley Bros. & Kelly, St. Paul.
Color, Coal Tar Dye.

Lab. No. 487.
Brand, Ketchup, Sunny Side.
Producer and Jobber, Tip Top Ketchup Co., Cincinnati, Ohio.
Retailer, H. V. Hicks & Son, Oakes.
Cost, .15.
Color, Coal Tar Dye.

Lab. No. 521.
Brand, Minnesota Favorite.
Producer and Jobber, M. A. Gedney, St. Paul.
Retailer, Chas. S. Kaufman, Bismarck.
Cost, .15.
Color, Coal Tar Dye.

Lab. No. 527.

Brand, Butler's Ketchup.
Producer and Jobber, Tip Top Ketchup Co., Cincinnati, Ohio.
Retailer, Jamison & Co., Mandan.
Cost, .10.
Color, Coal Tar Dye.

Lab. No. 549.

Brand, Tiger.
Producer and Jobber, Platte & Co., Baltimore, Md.
Retailer, Geo. Gussner, Bismarck.
Cost, .15.
Color, Coal Tar Dye.

Lab. No. 618.

Brand, Home Comfort.
Producer and Jobber, Brant Canning Co., Brant, N. Y.
Retailer, C. T. Studness, Churches Ferry.
Cost, .15.
Color, Coal Tar Dye.

Lab. No. 703.

Brand, Climax.
Producer and Jobber, Chas. F. Louden, Cincinnati, Ohio.
Retailer, Nimmo Bros., Devils Lake.
Color, Coal Tar Dye.

VINEGARS—ILLEGAL.

Lab. No.	Brand	Producers and Jobbers	Retailer	Spec. Grav.	Per Cent Acid	Solids	Ash	Color
75	Cider	O. L. Gregory, Paducah, Ky.	Patron's Exchange, Bottineau, N. D.	1.014	5.15	.56	.17	Colored
76	Prime Apple	M. A. Gedney, St. Paul.	Patron's Exchange, Bottineau, N. D.	1.011	4.80	.52	.09	Colored
87	Amazon Cider	Unknown.	Nash Bros., Grand Forks, N. D.	1.020	4.55	2.99	.09	Colored
95	White Wine	Unknown.	Nash Bros., Grand Forks, N. D.	1.022	9.52	.41	trace	
112	White Wine	A. M. Richter & Son, Manitowic, Wis.	Mr. Grant, Fargo	1.017	9.45	.35	trace	
140	Pure Cider	Knight, Stanley, Finney Co., Casselton, N. D.		1.011	5.79	1.64	.14	Colored
141	Cider	M. A Gedney, St. Paul, Minn.	Geo. H. Wilder, Grand Forks, N. D. (Too small sample)		5.42	1.62	.17	Colored
194	White Wine	Unknown.	Geo. R. Newell & Co., Minneapolis.	1.0125	4.68	.17	trace	
216	Cider	Cote Bros., St. Louis, Mo.	Jurgens Bros., Fargo.	1.005	4.85	.48	.02	Colored
394	Cider	Karl Birk, Moorhead, Minn.		1.0175	3.77	3.13	.41	
411	Cider	Unknown.	R. M. Yarrow, Fargo.	1.010	1.75	2.22	.27	
415	Cider	Unknown.	Anderson & Co., Fargo.	1.010	4.75	.43	trace	Colored
424	Apple Cider	M. A. Gedney, St. Paul.	P. J. Bergquist, Fargo,	1.014	4.62	.43	.01	Colored
443	Cider	Cote Bros., St. Louis.	Cramer Bros., Lisbon, N. D.	1.015	4.43	.37	.03	Colored
455	Cider	Unknown.	Joseph Goodman, Sheldon, N. D.	1.010	5.00	.48	.03	Colored

Lab. No.	Brand	Producers and Jobbers	Retailer	Spec. Grav.	Per Cent Acid	Solids	Ash	Color
469	45 grains	Winston, Harper, Fisher & Co Minneapolis, Minn.	C. S. Kratt, Sheldon, N. D.	1.015	4.37	.63	.05	Colored
486	Cider	Clarkville Vinegar Co., Clarkville, Mo.	Ramharter Bros., Oakes, N. D.	1.015	4.00	1.28	.10	Colored
502	Cider	Unknown.	Kuch & Zinck, La Moure, N. D.	1.015	5.11	.68	.11	Colored
514	Cider	Cote Bros., St. Louis, Mo.	Hurly Bros., Forman, N. D.	1.013	4.75	.48	.05	Colored
536	Double Strength	Unknown.	J. C. Swett, Bismarck, N. D.	1.020	9.11	.71	.04	Colored
538	Cider	M. A. Gedney, St. Paul, Minn.	H. L. Michelson, Bismarck, N. D.	1.015	5.12	1.51	.14	Colored
543	Cider	M. A. Gedney, St. Paul, Minn.	Wm. O'Hara, Bismarck, N. D.	1.0175	5.75	.96	.13	Colored
547	Cider	Unknown.	Geo. Gussner, Bismarck, N. D.	1.015	5.12	.73	.09	Colored
557	Cider	Unknown.	Box Car, Geo. Muldrum.	1.009	3.88	.31	.05	Colored
570	Amazon	Nash Bros., Grand Forks, N. D.	Larimore Packing Co.	1.020	4.45	3.55	.10	Colored
577	Amazon	Made at Davenport, Ill.	Salstad & Booker, Grand Forks, N. D.	1.020	4.55	2.75	.12	Colored
597	Cider	Nash Bros., Grand Forks, N. D.	W. F. Perry, Grand Forks, N. D.	1.012	4.87	.33	.04	Colored
630	Cider	M. A. Gedney, St. Paul, Minn.	P. A. Jorgenson, Grafton, N. D.	1.016	6.88	.55	.04	Colored
657	Cider	M. A. Gedney, St. Paul, Minn.	W. Crawford & Son, Neche, N. D.	1.009	4.05	.61	.11	Colored
658	Cider	O. L. Gregory, Paducah, Ky.	W. Crawford & Son, Neche, N. D.	1.017	5.80	.82	.12	Colored
662	Cider	Red Cross Co., St. Louis, Mo.	D. W. Young, Neche, N. D.	1.011	4.58	.19	trace	Colored

Lab. No.	Brand	Producers and Jobbers	Retailer	Spec. Grav.	Per Cent Acid	Solids	Ash	Color
671	Cider	Made at Davenport, Iowa.	Murphy, Holmes & Co., Neche, N. D.	1.012	5.25	.22	.03	Colored
713	Cider	Cote Bros., St. Louis, Mo.	P. de Fiore, Devils Lake, N. D.	1.012	5.43	.36	trace	Colored
780	White Wine	Burdick & Lincoln, Fargo, N. D.		1.018	9.12	.29	trace	

VINEGARS—PASSED.

Lab. No.	Brand	Producers and Jobbers	Retailer	Spec. Grav.	Per Cent Acid	Solids	Ash
77	Pure Apple Cider	H. J. Heinz & Co., Pittsburg, Pa.	Fred Blumer, Ellendale, N. D.	1.022	4.95	2.82	.25
78	Pure Apple Juice	S. R. & I. C. Motts, St. Louis, Mo.	Fred Blumer, Ellendale, N. D.	1.020	5.80	2.87	.34
128	N. Y. State Cider	Wright, Clarkson Merc. Co., Duluth, Minn.		1.022	4.85	2.66	.36
193	Cider	Genesse Fruit Co., Lansing, Mich.	Geo. R. Newell & Co., Minneapolis, Minn.	1.017	5.127	2.34	.28
322	Apple Cider	Jerse Norton, Duluth, Minn.		1.020	4.70	2.77	.29
323	Cider	O. L. Gregory, Paducah, Ky.	Fargo Mercantile Co., Fargo, N. D.	1.020	4.85	2.66	.38
396	Pure Cider	Natz & Co.,	Fred Blumer, Ellendale, N. D.	1.019	4.97	2.72	.29
437	Cider	Clarkville Cider Co., Clarkville, Mo.	M. T. Davis & Co., Lisbon, N. D.	1.020	3.87	4.23	.18
465	Amazon Cider	Made at Davenport, Iowa.	M. Gardner, Lisbon, N. D.	1.020	4.77	3.08	.10
566	Pure Cider	Bismarck Grocery Co.,			5.25	2.79	.33
599	Elko Cider	Wallace & Gregory, Paducah, Ky.	Fargo Grocery, Fargo, N. D.	1.022	4.77	2.97	.36

Lab. No.	Brand	Producers and Jobbers	Retailer	Spec. Grav.	Per Cent Acid	Solids	Ash
725	Cider	M. A. Gedney, St. Paul, Minn.	A. D. Sprague, Devils Lake, N. D.	1.019	5.20	2.49	.28
749	Cider	Winston, Harper, Fisher & Co., Minneapolis, Minn.	Scott & Barrett Mercantile Co., Lakota, N. D.	1.015	5.10	2.43	.23
785	Pure Cider	Burdick & Lincoln, Fargo, N. D.		1.019	4.70	2.45	.50

VINEGARS—LEGAL

Lab. No.	Brand	Producers and Jobbers	Retailer	Spec. Grav.	Per Cent Acid	Solids	Ash
298	Cider	Unknown.	T. E. Yerxa, Fargo, N. D.	1.0225	4.58	3.92	.45
416	Home	Griggs, Cooper & Co., St. Paul, Minn.	Pure Food Depot, Fargo, N. D.	1.020	5.35	3.35	.73
420	Cider	S. R. & J. C. Mott, St. Louis, Mo.	Fulton's Market, Fargo, N. D.	1.015	4.70	2.45	.23
427	Cider	H. J. Heinz & Co., Pittsburg, Pa.	W. B. Howland, Fargo, N. D.	1.020	4.95	2.59	.25
454	Cider	Clarkville Vinegar Co., Clarkville, Mo.,	C. Durgin, Sheldon, N. D.	1.020	4.10	3.65	.27
474	Apple Cider	S. B. & J. C. Mott, St. Louis, Mo.	M. Grange, Sheldon, N. D.	1.020	4.75	2.79	.24
475	Cider	H. J. Heinz & Co., Pittsburg, Pa.	M. Grange, Sheldon, N. D.	1.020	5.50	2.70	.40
494	Cider	Griggs, Cooper & Co., St. Paul, Minn.	Klein & Sutmar, Oakes, N. D.	1.025	5.87	3.30	.47
499	Cider	H. J. Heinz & Co., Pittsburg, Pa.	Cunningham & Lawrence, La Moure, N. D.	1.020	4.82	2.71	.37
506	Cider	S. B. & J. C. Mott, St. Louis, Mo.	Deisem & Franks, La Moure, N. D.	1.020	4.75	2.58	.28
520	Cider	F. C. Johnson, Kishwaukee, Wis.	McGillis Grocery Co., Mandan, N. D.	1.020	4.87	2.01	.36

Lab. No.	Brand	Producers and Jobbers	Retailer	Spec. Grav.	Per Cent Acid	Solids	Ash
526	Cider	Bismarck Grocery Co., Bismarck, N. D.	Jamison & Co., Mandan, N. D.	1.020	4.80	2.61	.41
567	Cider	Grand Forks Mercantile Co., Grand Forks, N. D.	L. Stern, Larimore, N. D.	1.020	4.85	2.76	.23
576	Cider	Genesse Vinegar Co., Lansing, Mich.	C. H. Howland, Grand Forks, N. D.	1.020	4.62	2.37	.32
580	Cider	Genesse Vinegar Co,. Lansing, Mich.	M. W. Hansen & Co., Grand Forks, N. D.	1.020	4.60	2.77	.33
588	Cider	Genesse Vinegar Co., Lansing, Mich.	R. B. Griffith, Grand Forks, N. D.	1.017	4.42	2.80	.33
589	Cider	Genesse Vinegar Co., Lansing, Mich.	Geo. H. Wilder, Grand Forks, N. D.	1.017	4.50	2.88	.33
591L	Cider	Genesse Vinegar Co., Lansing, Mich.	K. M. Nass & Co., Grand Forks, N. D.	1.020	4.72	2.70	.40
592	Cider	H. J. Heinz & Co., Pittsburg, Pa.	Johnson & McGowen, Grand Forks, N. D.	1.012	5.22		
598		Unknown.	C. J. Calmer, Fargo, N. D.		4.25	2.31	.26
635	Cider	F. C. Johnson, Kishwaukee, Wis.	H. J. Sprague, Grafton, N. D.	1.017	5.45	1.95	.34
744	Pure Apple	Barrett & Barrett, St. Paul, Minn.	Pinkerton & Kellog, Lakota, N. D.	1.018	4.63	2.39	.40
759A	Cider	O. L. Gregory, Paducah, Ky.	R. M. Yarrow, Fargo, N. D.	1.018	4.35	2.68	.36
779	Cider	O. L. Gregory, Paducah, Ky.	Grand Forks Mercantile Co., Grand Forks, N. D.	1.020	4.87	2.93	.36

From the foregoing it will be seen that a large percentage of the vinegars sold in North Dakota, as pure cider vinegars, are only imitation products colored to resemble cider vinegar.

The coloring of distilled and malt vinegars is in direct violation of Section Two of the food law, and where such vinegars are found to be so colored they will be classed as illegal and the retailers are liable to prosecution.

LEMON EXTRACTS.

"A standard lemon extract or essence is made in accordane with the United States Pharmacopœia and should contain 5 per cent of lemon oil.

An extract so made gave, by polariscope reading and using the factor 62.5, as the per cent of oil 4.81, therefore, an extract weaker than this could not be considered as standard. In judging of extracts we shall use this as the standard of comparison."

A lemon extract must not be colored to be standard and legal in North Dakota. The use of color tar dyes is prohibited in all food products.

Since making our last report, published as Bulletin No. 53 of the North Dakota Experiment Station we have examined eighty samples of lemon extracts, and of these sixty-seven or seventy-eight per cent are in non-compliance with the law, and the majority are of little or no real value, being wholly artificial, while the great majority are colored with coal tar dyes. We have divided these extracts in two groups, those which are of standard strength and legal; and a second group, below standard in strength and illegal.

Manufacturers, merchants, and consumers would do well to take note of those not legal in the state, for only pure goods, free from foreign color are to be permitted when the present stock is disposed of. No goods will be exempt after January 1, 1904.

LEMON EXTRACTS, LEGAL.

92	Brand	Extra High Grade
	Producers,	Eddy & Eddy, St. Louis, Mo.
	Alcohol	High
	Oil of Lemon	8.23 per cent
	Color	
	Legal and of high strength oil.	

93	Brand	Double Strength
	Producers,	Nash Brothers, Grand Forks, N. D.
	Alcohol	Good
	Oil of Lemon	4.78 per cent
	Color	
	Not full of strength.	

127 Brand .... Purity Triple
Producers, ...Purity Chemical Co., Chicago, Ill.
Alcohol .... Good
Oil of Lemon .... 5.00 per cent
Color .... Foreign
This color should be left out to be legal.

130 Brand .... Concentrated
Producers .... Winston, Harper, Fisher & co., Minneapolis
Alcohol .... High
Oil of Lemon .... 5.62 per cent
Color .... ?

182 Brand .... Puritan
Producers, ...Park Grant & Morris, Fargo, N. D.
Alcohol .... High
Oil of Lemon .... 5.50 per cent
Color .... Natural

219 Brand ....
Producers, ...Thompson, Taylor Spice Co., Chicago, Ill.
Alcohol .... High
Oil of Lemon .... 5.50 per cent
Color .... Natural

378 Brand .... Dainty
Producers, ...J. H. Allen & Co., St. Paul, Minn.
Alcohol .... High
Oil of Lemon .... 5.93 per cent
Color ....

379 Brand .... *B.*
Producers ....Griggs Cooper & Co., St. Paul, Minn.
Alcohol .... Good
Oil of Lemon .... 4.69 per cent
Color .... ?
Sample below standard and color questionable.

380 Brand .... A.
Producers ....Griggs, Cooper & Co., St. Paul Minn.
Alcohol .... High
Oil of Lemon .... 5.00 per cent
Color .... Natural

451	Brand	Imperial
	Producers	Karles Medicine Co., Aberdeen, S. D.
	Retailer	W. A. Cole, Lisbon, N. D.
	Alcohol	Good
	Oil of Lemon	5.50 per cent
	Color	?

586	Brand	Booths
	Producers	Booths Medicine Co. St. Cloud, Minn.
	Retailers	R. B. Griffith, Grand Forks, N. D.
	Alcohol	High
	Oil of Lemon	8.50 per cent
	Color	Natural

622	Brand	Gillett's
	Producers	E. W. Gillett, Chicago Ill.
	Retailers	C. W. Moore & Son, Grafton, N. D.
	Alcohol	High
	Oil of Lemon	5.62 per cent
	Color	(?)

629	Brand	Home
	Producers	Griggs, Cooper & Co., St. Paul, Minn.
	Alcohol	Good
	Oil of Lemon	4.72 per cent
	Color	(?)

Oil rather low and color probably foreign.

637	Brand	Fort Snelling
	Producers	Foley Bros. & Kelly St. Paul Minn.
	Alcohol	High
	Oil of Lemon	6.24 per cent
	Color	Natural

695	Brand	Red Dragon
	Producers	Bell Conrad & Co., Chicago, Ill.
	Retailers	Devils Lake Co-operative Association
	Alcohol	Good
	Oil of Lemon	4.84 per cent
	Color	(?)

Rather low and color questionable.

721	Brand	Atlas Triple
	Producers	Reid, Murdoch & Co., Chicago, Ill.
	Retailers	P. de Fioro, Devils Lake, N. D.

Alcohol .... High
Oil of Lemon .... 5.18 per cent
Color .... Foreign
Of good strenght but colored.

727 Brand .... Mrs. Fosters
Producers ....Not given, Duluth, Minn.
Retailers .... A. D. Sprague, Devils Lake, N. D.
Alcohol .... High
Oil of Lemon .... 7.50 per cent
Color .... Natural
Name of maker should be given to be legal.

732 Brand .... Monarch
Producers .... Reid, Murdoch & Co., Chicago, Ill.
Retailer, F. W. Manns & Son, Devils Lake.
Alcohol .... High
Oil of Lemon .... 6.22 per cent
Color .... Foreign
This product is of good strength but improperly colored.

783 Brand .... Booth's
Producers ....Booth Medicine Co., St. Cloud, Minn.
Retailers ....E. A. Perry, Fargo, N. D.
Alcohol .... High
Oil of Lemon ....10.13 per cent
Color .... Natural

BELOW STANDARD AND ILLEGAL.

The following extracts are below standard strength, illegally branded or contain a foreign coloring matter. In some instances the name of the manufacturer is not given. I have come to look with suspicion upon goods when the manufacturers do not care to have the public know that they are the makers of such goods. There is another class of manufacturers who have assumed fictitious names as manufacturers for their inferior goods so that when found out the reputation of their house should not be injured by the exposure. One firm is doing business under four distinct firm names. The public should consider the advisability of purchasing food products bearing these names, for it is pretty good prima facie evidence that they, the manufacturers, have something that will not bear inspection.

Some of the goods classed here as illegal I have every reason to believe will be made to comply with the law and remain as legitimate products on the market. The other brands will have to be removed from the market after January 1st.

52 Brand .... Fruit
Producers ......McCormick, Behnke & Co., St. Paul, Minn.
Alcohol .... Low
Oil of Lemon .... None
Color .... Artifical
Illegal.

54 Brand .... Palace
Producers ....McCormick, Behnke & Co., St. Paul, Minn.
Alcohol .... Low
Oil of Lemon .... None
Color .... Artifical
Illegal.

56 Brand .... Seal
Producers ....McCormick, Behnke & Co., St. Paul, Minn.
Alcohol .... Low
Oil of Lemon .... None
Color .... Illegal
Illegal.

64 Brand .... Chapman's
Producers .... Chapman, Smith Co., Chicago, Ill.
Alcohol .... Medium
Oil of Lemon .... 5.78 per cent
Color .... Artifical
Illegal. Colored with coal tar dye, but of good strength.

89 Brand .... Blue Ribbon
Producers ....Nash Brothers, Grand Forks, N. D.
Alcohol .... Low
Oil of Lemon .... None
Color .... Artifical
Illegal

131 Brand .... Triple
Producers ......Winston, Harper,Fisher & Co., Minneapolis
Alcohol .... Low
Oil of Lemon .... .62 per cent
Color .... Foreign
Illegal.

132 Brand .... Climax
.. Producers ....Winston, Harper, Fisher Co., Minneapolis.
Alcohol .... Low
Oil of Lemon .... None
Color .... Foreign
Illegal.

146 Brand .... Robin
Producers ....J. H. Allen & Co. St. Paul, Minn.
Alcohol .... Low
Oil of Lemon 2 per cent .... None
Color .... Foreign
Illegal.

147 Brand .... Dainty
.. Producers ....J. H. Allen & Co. St. Paul, Minn.
Alcohol .... Low
Oil of Lemon .... None
Color ....
Illegal.

203 Brand .... Pure
Producers ....Home Tea Co., Grand Forks, N. D.
Alcohol .... Low
Oil of Lemon .... 2.30 per cent
Color .... Coal Tar Dye
Illegal.

220 Brand ....
Producers ......Thompson, Taylor Spice Co., Chicago, Ill.
Alcohol .... Low
Oil of Lemon .... None
Color .... Natural
Illegal.

307 Brand .... Standard
Producers ....F. L. Frary & Co., Minneapolis, Minn.
Alcohol .... Low
Oil of Lemon .... None
Color ....
Illegal.

308 Brand .... Belmont
Producers ....F. L. Frary & Co., Minneapolis, Minn.
Alcohol .... Low

Oil of Lemon .... None
Color .... Foreign
Illegal.

375 Brand .... Lagneb
Producers ....Griggs, Cooper & Co., St. Paul, Minn.
Alcohol .... Low
Oil of Lemon .... .15 per cent
Color .... Natural
Illegal.

376 Brand ....
Producers ....Foley Bros. & Kelly, St. Paul, Minn.
Alcohol ....
Oil of Lemon .... None
Color ....
Illegal.

412 Brand .... Sampson's
Producers ....S. J.. Vidger & Co., Fargo, N. D.
Retailer ....R. M. Yarrow, Fargo, N. D.
Alcohol .... Low
Oil of Lemon .... .66 per cent
Color .... Coal Tar Dye
Illegal.

418 Brand .... Home
Producers ....Griggs, Cooper & Co. St. Paul, Minn.
Sold by ....Pure Food Depot, Fargo, N. D.
Alcohol .... Medium
Oil of Lemon .... 3.59 per cent
Color .... Foreign
Illegal. Contains foreign color and below standard.

422 Brand .... Standard
Producers ......Standard Chemical Works, St. Louis, Mo.
Sold by .... Fulton Market, Fargo, N. D.
Alcohol .... Low
Oil of Lemon .... None
Color .... Coal Tar Dye
Illegal..

426 Brand ....
Producers ......Thompson, Taylor Spice Co., Chicago, Ill.
Sold by .... P. J. Bergquist, Fargo, N. D.

Alcohol .... Low
Oil of Lemon .... 1.09 per cent
Color ....Coal Tar Dye
Illegal.

428 Brand .... Bastines
Producers .... Bastine & Co., New York, N. Y.
Retailer ....W. B. Howland, Fargo, N. D.
Alcohol .... Fair
Oil of Lemon .... 3.12 per cent
Color .... Natural
Pure but low in strength.

438 Brand .... Pure Concentrated
Producers ....M. S. Davis & Co., Lisbon, N. D.
Retailer .... M. S. Davis & Co., Lisbon, N. D.
Alcohol .... Low
Oil of Lemon .... .62 per cent
Color .... Foreign
Illegal.

444 Brand .... Jewell concentrated
Producers ......Stone, Ordean, Wells & Co., Duluth, Minn.
Retailers, ...Cramer Brothers, Lisbon N. D.
Alcohol .... Low
Oil of Lemon .... 1.56 per cent
Color ....Coal Tar Color
Illegal.

450 Brand .... Mrs. Baker's
Producers ...... Geo. R. Newell & Co. Minneapolis Minn.
Retailer ....W. A. Cole Lisbon N. D.
Alcohol .... Low
Oil of Lemon .... 1.37 per cent
Color ....Coal Tar Dye
Illegal.

458 Brand .... Pure Food
Producers .... Joseph Goodman, Sheldon, N. D.
Retailer, ...Joseph Goodman, Sheldon, N. D.
Alcohol .... Low
Oil of Lemon .... 1.06 per cent
Color .... Foreign
Illegal.

462. Brand .... Anchor
Producers ....—— St. Paul, Minn.
Retailer .... A. A. Burgess, Sheldon N. D.
Alcohol .... Low
Oil of Lemon .... .69 per cent
Color ....Coal Tar Dye
Illegal.

467 Brand .... Clear Quill
Producers .... Corbin Sons & Co., Chicago, Ill.
Retailer .... M. Gardner, Lisbon, N. D.
Alcohol .... Good
Oil of Lemon .... 5.62 per cent
Color .... Foreign
Of good strength but colored with what reacts as coal tar dye.

477 Brand .... Standard
Producer ....Boston Chemical Works, Boston, Mass.
Retailer .... Marion Grange, Sheldon, N. D.
Alcohol .... Low
Oil of Lemon .... .62 per cent
Color .... Foreign
Illegal.

478 Brand .... Star
Producer .... Star Extract Co., Chicago Ill.
Retailer ....Marion Grange, Sheldon, N. D.
Alcohol .... Low
Oil of Lemon .... .50 per cent
Color ....Coal Tar Dye
Illegal.

483 Brand .... Nichols
Producers .... Unknown
Retailers .... Ramharter Bros, Oakes, N. D.
Alcohol .... Medium
Oil of Lemon .... 1.35 per cent
Color .... Natural
Pure but of low strength.

503 Brand .... Concentrated
Producer .... John Kneen, La Moure, N. D.
Retailer .... Kuch & Zinck, La Moure, N. D.
Alcohol .... Medium

Oil of Lemon .... 1.12 per cent
Color ....Coal Tar Dye
Illegal.

508 Brand .... Jewel Concentrated
Producers ...... Stone, Ordean, Wells Co., Duluth, Minn.
Retailers .... Deisem & Franks, La Moure, N. D.
Alcohol .... Medium
Oil of Lemon .... 1.50 per cent
Color ....Coal Tar Dye
Illegal.

512 Brand .... Our Leader
Producers .... Hurley Brothers, Forman, N. D.
Retailer .... Hurley Brothers, Forman, N. D.
Alcohol .... Low
Oil of Lemon .... .62 per cent
Color ....Coal Tar Dye
Illegal.

528 Brand .... Perfection
Producer .... Atwood & Steel, Chicago, Ill.
Retailer .... Chas. Kupitz, Bismarck, N. D.
Alcohol .... Medium
Oil of Lemon .... 1.37 per cent
Color .... Foreign
Illegal.

532 Brand .... Double Extract
Producers .... Atwood & Steele, Chicago, Ill.
Retailer .... John Yeger, Bismarck, N. D.
Alcohol .... Medium
Oil of Lemon .... 3.44 per cent
Color .... Foreign
Illegal, and improperly labeled.

534 Brand .... Tillman's
Producers .... Tillman & Bendel, San Francisco, Cal.
Retailers, ... John Yeger, Bismarck, N. D.
Alcohol .... Medium
Oil of Lemon .... 1.35 per cent
Color ....Coal Tar Dye
Illegal.

544	Brand	Favorite
	Producers	Winter Spice Co., Chicago Ill.
	Retailer	Wm. O'Hara, Bismarck, N. D.
	Alcohol	Low
	Oil of Lemon	.31 per cent
	Color	Foreign
	Illegal.	
550	Brand	Kent's Nectar
	Producer	W. H. Kent, St. Paul, Minn.
	Retailer	Geo. Gussner, Bismarck, N. D.
	Alcohol	Medium
	Oil of Lemon	1.35 per cent
	Color	Foreign
	Illegal.	
551	Brand	Hoosier
	Producers	Atwood & Steele, Chicago, Ill.
	Retailer	Geo. Gussner, Bismarck, N. D.
	Alcohol	Low
	Oil of Lemon	.62 per cent
	Color	Foreign
	Illegal.	
552	Brand	Pure & True
	Producers	Minnesota Spice & Mercantile Co., St. Paul.
	Retailer	Geo. Gussner, Bismarck, N. D.
	Alcohol	Medium
	Oil of Lemon	1.35 per cent
	Color	Coal Tar Dye
	Illegal.	
560	Brand	Meldrum's Triple
	Producer	Geo. Meldrum, Chicago, Ill.
	Alcohol	Fair
	Oil of Lemon	4.40 per cent
	Color	Foreign
	Illegal.	
571	Brand	Brook's Diamond
	Producer	L. A. Brooks, Larimore, N. D.
	Retailer	Larimore Packing Co., Larimore, N. D.
	Alcohol	High
	Oil of Lemon	9.37 per cent

Color .... Coal Tar Dye
This is exceptionally high in strength, but improperly colored with coal tax color.

587 Brand .... Double Strength Honest Bottle
Producers .... Wm. McMurray & Co., St. Paul, Minn.
Retailer .... R. B. Griffith, Grand Forks, N. D.
Alcohol .... Medium
Oil of Lemon .... 1.06 per cent
Color ....
Illegal. Very low in strength and colored with what seems to react for coal tar dye.

593 Brand .... Pure Food
Producer .... Johnson & McGowan, Grand Forks, N. D.
Retailer ...... Johnson & McGowan, Grand Forks, N. D.
Alcohol .... Low
Oil of Lemon .... .93 per cent
Color .... Foreign
Illegal.

596 Brand .... Seely's
Producers ......Seely Manufacturing Co., Detroit, Mich.
Retailer .... W. F. Perry, Grand Forks.
Alcohol .... Medium
Oil of Lemon .... 1.56 per cent
Color .... Coal Tar Dye
Illegal.

608 Brand .... Dainty
Producers .... J. H. Allen & Co., St. Paul, Minn.
Retailer .... S. S. Moen, Churches Ferry, N. D.
Alcohol .... Good
Oil of Lemon .... 4.38 per cent
Color .... Foreign

617 Brand .... Souder's
Producers .... Royal Remedy & Extract Co., Dayton, Ohio.
Retailers .... C. T. Studness, Churches Ferry, N. D.
Alcohol .... Low
Oil of Lemon .... None
Color .... Foreign
Illegal.

638 Brand .... Kenwood
Producers .... Kenwood Mfg. Co., Chicago, Ill.

Alcohol .... Low
Oil of Lemon .... None
Color .... Foreign

644 Brand .... Standard
Producer .... Grand Forks Mercantile Co.
Retailer .... Chas. Moen & Son, Grafton, N. D.
Alcohol .... Low
Oil of Lemon .... .88 per cent
Color .... Foreign

646 Brand .... Standard
Producers .... Grand Forks Mercantile Co.
Retailers .... W. Crawford & Son, Neche, N. D.
Alcohol .... Low
Oil of Lemon .... 1.25 per cent
Color .... Foreign

648 Brand .... Standard
Producers .... Gillett's Chemical Works, Chicago, Ill.
Retailers .... W. Crawford & Son, Neche, N. D.
Alcohol .... Low
Oil of Lemon .... None
Color .... Foreign

649 Brand .... Gold Medal
Producers, Grand Forks Mercantile Co., Grand Forks, N. D.
Retailers .... W. Crawford & Son, Neche, N. D.
Alcohol .... Low
Oil of Lemon .... .81 per cent
Color .... Foreign

650 Brand .... Economy
Producers .... Geo. R. Newell & Co., Minneapolis, Minn.
Alcohol .... Low
Oil of Lemon .... 1.81 per cent
Color .... Foreign

663 Brand .... Crescent
Producers, Lenning, Brown, Wright & Co., Crookston, Minn.
Alcohol .... Low
Oil of Lemon .... .38 per cent
Color .... Foreign

668 Brand .... Standard
Producers .... F. L. Frary & Co., Minneapolis, Minn.

	Retailers	Murphy, Holmes & Co., Neche N. D.
	Alcohol	Low
	Oil of Lemon	None
	Color	Foreign
693	Brand	Columbia
	Producers	H. B. Straight & Co., St. Paul, Minn.
	Retailers	Devils Lake Co-operative Association.
	Alcohol	Low
	Oil of Lemon	None
	Color	Foreign
696	Brand	Robin
	Producers	J. H. Allen && Co., St. Paul, Minn.
	Retailers	Devils Lake Co-operative Association
	Alcohol	Low
	Oil of Lemon	None
	Color	Foreign
705	Brand	Fruit
	Producers	McCormick, Behnke & Co., St. Paul, Minn.
	Retailers	Nimmo Bros., Devils Lake, N. D.
	Alcohol	Low
	Oil of Lemon	None
	Color	Foreign
719	Brand	Seal
	Producers	Kenwood Preserving Co., Chicago, Ill.
	Retailers	P. de Fiore, Devils Lake, N. D.
	Alcohol	Low
	Oil of Lemon	None
	Color	Foreign
728A	Brand	Triple
	Producers	Winston, Harper, Fisher & Co., Minneapolis.
	Retailers	A. D. Sprague, Devils Lake, N. D.
	Alcohol	Low
	Oil of Lemon	None
	Color	Foreign
731	Brand	Bengal
	Producers	Not given on package.
	Retailers	F. W. Manus & Son, Devils Lake, N. D.
	Alcohol	Low
	Oil of Lemon	None
	Color	Foreign

737 Brand .... Gillett's Double Strength
Producers .... E. W. Gillett, Chicago, Ill.
Alcohol .... High
Oil of Lemon .... 5.17 per cent
Color .... Foreign
Improperly labeled double strength when only slightly above required official standard strength and is colored with foreign color.

745 Brand .... Blue
Producers .... Seabury & Co. St. Paul, Minn.
Retailers .... Monson Bros. & Co., Brocket, N. D.
Alcohol .... Medium
Oil of Lemon .... 4.06 per cent
Color .... Foreign

747 Brand .... Satisfaction Concentrated
Producers .... Rush Chemical Co., no address given.
Retailers .... Math Vobayda, Lawton, N. D.
Alcohol .... Low
Oil of Lemon .... None
Color .... Foreign

751 Brand ....
Producers .... Thompson, Taylor Spice Co., Chicago, Ill.
Retailers .... Hutchins & Libby, Lakota, N. D.
Alcohol .... Low
Oil of Lemon .... None
Color .... Foreign

780 Brand .... Three per cent. Gold Medal
Producers .. Grand Forks Mercantile Co., Grand Forks
Alcohol .... Low
Oil of Lemon .... 1.09 per cent
Color .... Foreign

781 Brand .... One per cent. Peerless
Producers, Lenning, Brown, Wright & Co., Crookston, Minn.
Sent in by .... J. W. Rush, Chicago, Ill.
Alcohol .... Low
Oil of Lemon .... .62 per cent
Color .... Foreign

As will be observed from an inspection of the analysis of Lemon extracts given in the preceding pages, it is very evident that a large proportion have very little to commend them to the consumer. There is little wonder that the use of lemon extract has rapidly decreased in those localities where these spurious products are being sold. One of the leading manufacturers in writing me makes the following statement which may be of interest to those making a study of extracts.

"Touching the matter of lemon extract especially, it would seem necessary to establish a standard of Oil of Lemon, for it may be news to you, and it may not, that there are coming into use more and more varying standards of Oil of Lemon. For instance, a large operator in oil of lemons offers us ta-day a certain grade of Oil of Lemon at 45 cents per pound. The next grade or what they call "second quality" at 57 1-2 cents per pound. What they call standard oil of lemon, which presumably is about the average of the better grades of oil oflemon, they offer at 60 cents per pound. Furthermore, they have what they call "extra strong" oil of lemon at $10.00 per pound. They also offer Turpenless Oil of Lemon at $26.00 per pound.

Now this same operator in oil of lemon could go to an ordinary so called extract manufacturer, who is in reality simply a mixer, and he could sell this 45 cent oil of lemon to him at 75 cents or goods at 57 1-2 cents for 60. In other words, there is a great army of people puttering in the extract business who have no more idea of what constitutes value in oil of lemon than they have of any other thing that they have not made a study of. Some of these same operators claim that the Turpenless Oil of Lemon is thirty times stronger than the ordinary standard oil of lemon of good quality. They also claim that Turpenless Oil of Lemon can be made up into flavoring extract with 15 per cent of alcohol and 85 per cent of water while with the standard oil of lemon 85 per cent or 90 per cent of alcohol is required and the balance water.

For our own part, we believe that there is a good deal of humbug in this Turpenless Oil of Lemon, and our own opinion, based upon practical experience in making flavoring extracts for twenty-five years, is that a good, clean, fruity oil of lemon with the larger part of the greasy, insoluble, flavorless portion of the oil removed, then by using 5 1-2 per cent to 6.0 per cent of this washed product, you will have a flavoring extract that will be strong, fruity and rich and also a flavor that will not deteriorate with age, as so much of the stuff does that is on the market. So that we would say for what would be called a high grade, fine quality extract, about 6 per cent of oil should be used, the oil being treated as indicated, washing out the mucilaginous, ropey substance that in our judgment should be eliminated.

"Possibly it may be known to you that Sanderson's oil of lemon that is generally known as standard brand and grade of oil of lemon, does not by any means represent the best value in oil of lemon. Sanderson was originally a silk merchant in New York, and during a trip in Europe he conceived the idea of putting on the market in this country a brand of oil of lemon. He went into the market with his buyers, buying up oil of lemon very much as a country merchant would buy up butter from the farmers. He took this oil of lemon, put it into a large tank, blended the different lots, filtered and canned and branded it, thus aiming to make a uniform grade in color and general quality. Just as the country merchant might blend forty makes of butter and thus secure a uniform color and standard of blending of the different makes. Sanderson's business grew as he was the pioneer along this line, and he became the oil of lemon merchant in this country, but since his death things have changed, and now the woods are full of manipulators and merchants and shippers of oil of lemon, and as far as we have investigated and studied the situation from personal visits to Italy, there are perhaps not more than three to five shippers and packers of oil of lemon that are really worthy of confidence, while there are many that are manipulators of oil of lemon. So that there is perhaps as much humbug in the oil of lemon business in Italy as in any other commodity, and the result of this sort of manipulation among the Italians is spreading into this country."

In our experience we have found also that several extract manufacturers are grinding the lemon oil with magnesia and extracting this with a low strength alcohol which results in an extract containing no real oil of lemon. The oil of lemon extracted from this magnesia residue is then disposed of to bakers and others at a good price.

The majority of extracts now being offered for sale in North Dakota will have to be taken off the market or be very materially improved in quality after January 1st, 1904.

VANILLA EXTRACTS.

Vanilla Extract shall be made wholly from vanilla beans macerated in alcohol, and shall be free from any coloring matter. Coloring matter added here must be deemed used for the purpose of concealing inferiority so as to deceive the purchaser.

When other substances are used; such as Vanillin, Coumarin, or Tonka, the extract should be labeled so as to show the purchaser its true character and not to deceive. The term "Compound Extract of Vanilla" is not a proper labeling.

VANILLA EXTRACTS, LEGAL.

The following extracts have been found to meet the requirements of the pure food law.

62 Brand .... Chapman's
Producer ....Chapman, Smith Co., Chicago, Ill.
Of good strength and legal.

90 Brand .... Eddy's High Grade
Producers ....Eddy & Eddy, St. Louis, Mo.
A pure vanilla weak in alcohol and held up by alkali.

133 Brand .... Concentrated
Producers .... Winston, Harper, Fisher & Co., Minneapolis.
A pure product of good strength.

143 Brand .... Dainty
Producers .... J. H. Allen & Co., St. Paul, Minn.
Apparently pure but of medium alcohol strength and cut with alkali.

144 Brand .... Blue Ribbon
Producers .... J. H. Allen & Co., St. Paul, Minn.
Probably pure, of medium strength alcohol and cut with alkali.

215 Brand .... Puritan
Producers .... Park, Grant & Morris, Fargo, N. D.
A pure extract of medium strength.

231 Brand .... No. 1.
Producers. .... Griggs, Cooper & Co., St. Paul.
Pure and legal.

413 Brand .... Puritan
Producers .... Park, Grant & Morris, Fargo, N. D.
Retailer .... R. M. Yarrow, Fargo, N. D.
Pure, of good quality and medium strength.

417 Brand .... Home
Producers .... Griggs, Cooper & Co., St. Paul, Minn.
Retailer .... Pure Food Depot, Fargo, N. D.
An extract of medium strength, but probably illegally colored.

421 Brand .... Club House
Producers ...... Franklin, McVeagh & Co., Chicago, Ill.
Retailer .... Fulton's Market, Fargo, N. D.
Seems to contain some foreign resin but of good strength.

429 Brand .... Bastins
Producers .... Bastin & Co., New York
Retailer .... W. B. Howland, Fargo, N. D.
An extract of medium strength.

430 Brand .... Dr. Prices.
Producers .... Prices Flavoring Extract Co., Chicago, Ill.
An extract of good strength.

439 Brand .... Jewell Concentrated
Producers ...... Stone, Ordean, Wells Co., Duluth, Minn.
Retailer .... M. S. Davis, Lisbon, N. D
Of medium strength.

457. Brand .... Golden Sheaf.
Producers .... Fargo Mercantile Co., Fargo. N. D.
Retailer .... Joseph Goodman Sheldon. N. D.
An extract of good strength, possibly containing a little color.

466 Brand .... Clear Quill
Producers .... Corbin Sons & Co., Chicago, Ill.
Retailer, ... M. Gardner, Lisbon. N. D
An extract of good strength.

470 Brand .... Special
Producers ......, Lakota Manufacturing Co., Chicago, Ill.
Retailers .... C. S. Kratt, Sheldon. N. D.
Mainly coumarin, with small amount of vanilla.

484 Brand .... Our Leader
Producers .... Ramharter Bros., Oakes, N. D.
Retailer .... Ramharter Bros. Oakes N. D.
Of medium strength but seems to be slightly colored.

489 Brand .... Victory
Producers .... Leach Gamble Dexter Co., Wapheton, N. D.
Retailer .... H. V. Hicks & Son, Oakes, N. D.
Of good strength.

504 Brand .... Pure Concentrated
Producer .... False Label
Retailer .... Kuch & Zink, La Moure, N. D.
Of medium strength but not properly labeled.

507 Brand .... Jewell
Producers ...... Stone, Ordean, Wells Co., Duluth, Minn.
Retailers .... Deisem & Franks, LaMoure, N. D.
Of medium strength and probably contains some color.

509 Brand .... Hiawatha
Producers ...... Stone, Ordean, Wells Co., Duluth, Minn.
Retailers .... Deisem & Franks, LaMoure, N. D.
Of good strength. Color (?)

529 Brand .... Pure Concentrated
Producers .... J. H. Bell & Co., Chicago, Ill.
Retailer .... Chas. Kupitz, Bismarck, N. D.
Of good strength. Color (?)

553 Brand .... Eddy's Extra High
Producers .... Eddy & Eddy, St. Louis, Mo.
Of good strength, but colored with caramel.

590 Brand .... Standard
Producers, Grand Forks Mercantile Co., Grand Forks, N. D.
Retailer .... Geo. Wilder, Grand Forks, N. D.
Of medium strength, colored.

634 Brand .... Seely's
Producers ...... Seely Manufacturing Co., Detroit, Mich.
Retailer .... H. G. Sprague, Grafton, N. D.
Of good strength.

636 Brand .... Fort Snelling
Producers .... Foley Bros. & Kelly, St. Paul, Minn.
Retailer .... J. La Moure & Co., Neche, N. D.
Pure but not very strong.

647 Brand .... Standard
Producers .... Gillett's Chemical Works, Chicago, Ill.
Retailers .... W. Crawford & Son, Neche, N. D.
Of good strength but color questionable.

733 Brand .... Monarch
Producers .... Reid, Murdoch & Co., Chicago, Ill.
Retailer .... F. W. Manns & Son, Devils Lake, N. D.
A pure product of medium strength.

746 Brand .... Blue
Producer .... Seabury & Co., St. Paul, Minn.
Retailer .... Monson Bros. & Co., Brocket, N. D.
Of medium strength but probably colored.

VANILLA ETRACTS NOT PROPERLY LABELED AND ILLEGAL.

51 Brand .... Fruit
Producers ...... McCormick, Behnke & Co. St. Paul Minn.
An artificial product of coumarin colored with caramel. Illegal.

53 Brand .... Palace
Producers .. McCormick, Behnke & Co., St. Paul, Minn.
A product of good strength, but colored with caramel, therefore illegal.

55 Brand .... Seal
Producers .... McCormick, Behnke & Co., St. Paul, Minn.
An artifical product colored with caramel improperly labeled therefore illegal.

91 Brand .... Double Strength
Producers .... Nash Brothers, Grand Forks, N. D.
An artificial product of medium strength.

94 Brand .... **Blue Ribbon**
Producers .... **Nash Brothers, Grand Forks, N. D.**
An artificial product made from vanallin and coumarin, colored with caramel. Not properly labeled, therefore illegal.

134 Brand .... Triple
Producers, Winston Harper, Fisher & Co., Minneapolis.
An artificial product of vanallin and courmarin colored with caramel. Improperly labeled, therefore illegal.

135 Brand .... Climax
Producers .... Winston, Harper, Fisher & Co., Minneapolis
Largely an artificial product of coumarin or tonka and colored with what appears to be coal tar dye.

145 Brand .... Robin
Producers .... J. H. Allen & Co., St. Paul, Minn.
An artificial extract. Illegal.

183 Brand .... Puritan
Producers .... Park, Grant & Morris, Fargo, N. D.
Not made by official method.

232 Brand .... No. 2.
Producers .... Griggs, Cooper & Co., St. Paul, Minn.
Of medium strength but colored with caramel, therefore not legal.

309 Brand .... Standard
Labeled Vanilla and Tonka.
Producers ...... F. L. Frary & Co., Minneapolis, Minn.
An artificial product not properly labeled.

310 Brand .... Belmont
Producers ...... F. L. Frary & Co., Minneapolis, Minn.
An artificial product of vanillin with some tonka or coumarin.

414 Brand .... Double Strength
Producer .... S. J. Vidger & Co., Fargo, N. D.
Retailer .... R. N. Yarrow, Fargo, N. D.
An artificial extract of coumarin, colored with caramel.

425 Brand .... Crown
Producer .... Fargo Mercantile Co., Fargo, N. D.
Retailer .... P. J. Bergquist, Fargo, N. D.
It is artificial, largely coumarin and colored with caramel.

461 Brand .... Anchor
Producer .... (No name.) St. Paul Minn.
Retailer .... A. A. Burgess, Sheldon, N. D.
An artificial product of coumarin, colored with caramel.

463 Brand .... Bengal
Producers .... Name not given
Retailer .... A. A. Burgess, Sheldon, N. D.
Not pure. Not properly labeled and manufacturers name not given.

471 Brand .... Gillett's Double
Producers .... E. W. Gillett, Chicago, Ill.
Retailer .... C. S. Kratt, Sheldon, N. D.
Improperly labeled and colored.

479 Brand .... Banquet
Producer .... Park Grant & Morris, Fargo, N. D.
Retailer .... Marion Grange Sheldon N. D.
An artificial product, mainly coumarin and coloreed with anilin.

480 Brand .... Star
Producers .... Star Extract Co., Chicago, Ill.
Retailer .... Marion Granger Sheldon, N. D.
An artifical product colored with caramel.

485 Brand .... Double Strength
Producers .... Ramharter Bros. Oakes, N. D.
Retailers .... Ramharter Bros. Oakes, N. D.
Cartoon labeled 2 oz. and bottle labeled 1 oz. Contains coumarin and not properly labeled.

513 Brand ....
Producers .... Hurly Bros., Forman, N. D.
Retailers .... Hurly Bros., Forman, N. D.
Mainly artificial, coumarin, colored.

533 Brand .... Double Strength
Producers .... Atwood & Steele, Chicago, Ill.
Retailers .... John Yegen, Bismarck, N. D.
Improperly labeled and misleading. Not double strength.

541 Brand .... Gold Medal
Producers .... Bismarck Grocery Co.
Contains coumarin and colored with anilin.

561 Brand .... Meldrum's Triple True
Producers .... Geo. Meldrum, Chicago, Ill.
Retailer .... "Box Car Merchant"
Contains coumarin, colored and not properly labeled.

572 Brand .... Brook's Diamond
Producers .... L. A. Brooks, Larimore, N. D.
Retailer .... Larimore Packing Co.
Largely an artificial product of coumarin and colored.

585 Brand .... Booth's
Producers .... Booth Medicine Co., St. Cloud, Minn.
Retailer .... R. B. Griffiths, Grand Forks, N. D.
Mainly coumarin and not properly labeled.

594 Brand .... Pure Food
Producers ...... Johnson & McGowan, Grand Forks, N. D.
Retailer ...... Johnson & McGowan, Grand Forks, N. D.
Wholly artificial coumarin, of medium strength and colored.

623 Brand .... Fruit
Producer .... McCormick, Behnke & Co., St. Paul, Minn.
Retailer .... Chas. W. Moore, Grafton, N. D.
Contains coumarin and colored.

624 Brand .... Seal
Producer .... McCormick, Behnke & Co., St. Paul, Minn.
Retailer .... Chas. W. Moore & Son, Grafton N. D.
Not pure and colored.

651 Brand .... Newell's Extra
Producer ...... Geo. R. Newell & Co., Minneapolis, Minn.
Retailer .... W. Crawford & Son, Neche, N. D.
Of good strength but highly colored.

664 Brand .... Crescent
Producer .... Lenning, Brown, Wright & Co., Crookston.
Retailer .... D. W. Young, Neche, N. D.
Contains coumarin and colored with anilin.

665 Brand .... Belmont
Producer .... F. L. Frary & Co., Minneapolis, Minn.
Retailer .... Murphy, Holmes & Co., Neche, N. D.
An artificial product of vanillin containing coumarin and colored with anilin.

667 Brand .... Vanilla and Tonka
Producers .... F. L. Frary & Co., Minneapolis, Minn.
Retailers .... Murphy, Holmes & Co., Neche, N. D.
An artificial product of coumarin and vanillin and colored with anilin. The top of the box was labeled "Vanilla."

694 Brand .... Robin
Producers .... J. H. Allen & Co., St. Paul, Minn.
Retailers .. ..Devils Lake Co-operative Association
A very weak extract, colored.

704 Brand .... Pure
Producers .... (Not given.) New York, Chicago.
Retailer .... Nimmo Bros., Devils Lake, N. D.
An artificial product of coumarin, colored with caramel.

748 Brand .... *Seal*
Producers .... Kenwood Preserving Co., Chicago, Ill.
Retailers ....Edmore Mercantile Co., Edmore, N. D.
Colored, of low strength, and illegal.

750 Brand ....
Producers ...... Thompson, Taylor Spice Co., Chicago, Ill.
Retailer .... Hutchins & Libby, Lakota, N. D.
Colored with anilin.

782 Brand, Vanilla and Tonka .... Booth's
Producers .... Name not given
Retailer .... E. A. Perry, Fargo, N. D.
Outer wrapper of package labeled "Vanilla" type not uniform and size and not properly labeled.
Manufacturer corrected label on notice from this deparment.

Coloring matter will not be permitted in extracts of any kind after July 1st, 1904. Caramel is now used, when shown on label, in artificial products and tonka extracts. This is to be illegal in the future and consumers should bear in mind that the artifical products are being colored to imitate the true Vanilla.

SACCHARIN AND ITS USE IN FOOD PRODUCTS.

Since the North Dakota Pure Food Law went into effect, there has been considerable discussion regarding the use of saccharin, and manufacturers of the artificial sweetener have claimed that the use of this product in foods should not be prohibited or restricted but that it should be classed as a condiment. Even manufacturers themselves within the past few months changed their line of argument to better enable them to defend the stand which they have chosen to take.

In sending out the law and ruling bearing thereon, we did not feel with the protests that were being made that it would be wise to prohibit the use of saccharin, but classed it as an antiseptic and preservative and stated that where used the cans or packages should bear the following label: "SWEETENED WITH SACCHARIN" or "CONTAINS SACCHARIN," and in type not less than two line pica in size.

That the manufacturers themselves claimed antiseptic properties for this product is indicated on every package sent out by the Monsanto Chemical Works previous to the time of this controversy. They also claimed that it was a sweetener like sugar and did not themselves class it as a condiment. I quote from one of their labels, "Saccharin 'Monsanto' refined pure, the perfect sweetener, five hundred and fifty times as sweet as sugar and purer and cleaner than sugar, healthful, economical and uniform, possesses antiseptic and preservative properties, will not ferment nor turn sour."

We quote from a few medical authorities, using only standard text books recognized and used in the medical colleges of the United States, the opinions there expressed with regard to the properties of saccharin.

Says Thomson, in his Practical Dietetics, page 118,—"It is antiseptic and has the property of acidifying the urine, being eliminated unaltered by the kidneys, hence it can be used medically in cases of pyelitis or cystitis. It may be given for months at a time without danger, if the quantity prescribed does not exceed more than two or three grams, three times a day. More than this dose may cause derangement."

In Sollman's text book of Pharmacology he states, "It is bebelieved by some that its long continued use may give rise to nephritis."

Says Dr. H. C. Wood, in his text book on Therapeutics, "Its solution (saccharin) has antiseptic properties, and in Plugge's numerous experiments it checked the action of ptyalin, pepsin, trypsin, and other allied ferments. Sawitzki, indeed, alleges that it depresses protied metabolism. In Bruylant's trials it failed to check artificial digestion, probably on account of the acidity of the solution, but as little as one per cent is enough to distinctly lessen the action of the pancreatic solution."

Says Dr. Butler, in his text book of Materia Medica, Therapeutics and Pharmacology,—"In a neutral or alkaline medium saccharin acts as an antiseptic. Internally it exerts no noticeable influence. It is said that when mixed with foods it interferes with the action of saliva upon the starch, and it is thought to retard the action of the other digestive ferments. The drug is not decomposed in the body, and is eliminated by the kidneys unchanged, increasing the amount of chlorides excreted in the urine, which fluid is so influenced by the drug that it does not readily undergo fermentation."

We find acording to the National Dispensatory; page 1393, that "Paul found a solution of it (saccharin,) 11,500 retarded the action of pepsin on egg albumin and of diatase on starch. This direct interference with assimilation of food caused the French government to prohibit its use as a dietetic substitute for sugar. The soda compound of saccharin does not exert this influence or does so very slightly, nor does saccharin itself when its dose is kept within proper bounds."

Dr. Wiley, chief chemist of the Department of Agriculture, said before the Senate Committee of the United States for the purpose of examining the conditions of food products as given on page 53, as follows, "It has no food value. It is an antiseptic. It prevents decay, and therefor retards digestion to that extent."

After the publication of Bulletin No. 53 showing something of extent of the adulteration of food products being offered for sale in North Dakota and a law had been introduced and passed by the legislative assembly of North Dakota prohibiting the use of such food products in the state, there sprang up considerable controversy both regarding the character of the work which we had done and the stand which we had taken against the use of certain chemical preservatices and coal tar dyes. A committee of interested packers backed by others visited Washington for the purpose of interviewing Dr. Wiley, and on their return, they published the results of their interview, to be distributed among the various packers. In a little controversy which arose later, Mr. A. C. Fraser of the Albert Landreth Co., Manitowoc, Wis., sent me a copy of the circular. In as much as the data contained therein has a direct bearing upon this mooted question and at the same time throws light upon several other points, I herewith reproduce the circular in full.

MEMORANDUM OF AN INTERVIEW WITH DR. H. W. WILEY,

CHIEF OF THE BUREAU OF CHEMISTRY, AGRICULTURAL DEPARTMENT, U. S. GOVERNMENT.

Washington, D. C., March, 16, 1903.

Present: A. C. Fraser, President of the Western Packers' Canned Goods Association; L. J. Risser, Member of the Executive Committee of the Western Packer's Canned Goods Association; O. L. Denning, Editor of the "Canner and Dried Fruit Packer;" and C. E. M. Newton, Representating the Commercial Exchange, Chicago.

Q. Dr. Wiley, what substance or chemical, if any, other than sugar, can be used to sweeten vegetables in the process of packing in hermetically sealed cans?

A. I have never heard of any other sweetener than sugar, except saccharin. There is no national law on the subject and this department has no legal jurisdiction. I can only refer you to the law governing imports, being the only law, the execution of which lies in the province of this department.

Q. Is the use of saccharin prohibited by law?

A. Yes, sir, it is.

Q. Dr. Wiley, do you believe saccharin to be injurious to health?

A. Yes sir, most certainly.

Q. Do you think it should not be used?

A. Yes, sir, I think it should not.

Q. And your department would sustain the action of any chemist deciding it to be injurious to health, and prohibiting its use in any state?

A. Yes, sir, it would, in my opinion.

Q. What substance, or chemical, can be used to bleach or whiten corn?

A. Bleaching can be done by sulphur or by exposure to sulphurous acid gas, if the corn is immediately exposed to heat, or a current of air to destroy the surplus gas. Bue the use of any sulphite placed in the can so as to be incorporated with the vegetable and so to bleach it, sustain its white color, should be absolutely prohibited.

Q. What substance, or chemical, can be used to color vegetables?

A. Coloring matter derived from vegetables is of course, harmless, and, in fact, has food values, but that derived from coal tar should be absolutely prohibited.

Q. Is it possible for formaldehyde, or any substance or chemical resembling it, to be formed in hermetically sealed cans by natural processes?

A. I have no knowledge that formaldehyde or any other aldehyde has ever been formed, but believe that such formation could occur; as whenever alcoholic fermentation occurs, formaldehyde would be apt to form and would then respond to the test.

Q. Is it easy to mistake some other substance for formalin or formaldehyde in any chemical analysis?

A. Yes, one has to be very careful that such an error does not occur.

Q. Can you individually or officially make an analysis of canned goods when requested to do so?

A. No, we cannot take up a matter of this kind for any manufacturer or trade. This department can only take cognizance of such matters when requested to do so by the officials of the various states.

It is plainly evident that under the existing conditions the above statement would not be overdrawn, as expressing the views of one highest in authority as chemical adviser, to the United States.

The matter of sulphites and formaldehyde will be discussed elsewhere.

I believe then that we would be justified under Section 2 of the North Dakota Pure Food Law, in prohibiting altogether the use of saccharin (coal tar sugar.) The use of saccharin is prohibited in imports. The best American authorities agree that it is harmful and foreigners prohibit its use. Passing over the question of harmfullness, it cannot be denied but what it is used as a sweetener in food products; in beverages, as beers and ciders; in canned goods, as corn, peas; and in preserves, jellies and jams; in sweet pickles and above all largely in candy.

That the use of saccharin in food products has increased enormously during the past five years, cannot be disputed. Why is it used? As a substitute for sugar. It has no food value but tends to deceive and does deceive the consumer, therefor the people have a right to know of its presence. One pound of saccharin, garantose or artificial sweetener (coal tar sugar) gives a sweetening effect equivalent to 550 pounds of the best granulated sugar, but furnishes no nutriment whatever and must be eliminated by the kidneys. At six cents a pound, the granulated sugar would cost $33 and is possessed of a large amount of food value, while coal tar sugar is worthless as a food even though it does not prove harmful.

If the presence of this product (coal tar sugar) in foods, tends to deceive or does deceive the consumer, then it is prohibited by the law of the state. It is also prohibited if it proves to be injurious as the evidence submitted, shows it to be, since it retards digestion, lowers proteid metabolism and its continued use may cause nephritis. It is also prohibited if used as an imitation or substitute for sugar or its presence reduces or lowers the quality or strength of the food product when offered for sale.

The manufacturers of sacharin, garantose, or artificial sweetener (coal tar sugar) are making a strong fight to win the public and have not hesitated to resort to questionable methods in belittling the work of this department. It is quite evident that the courts must decide the question as to whether the use of coal tar sugar is to be permitted without due notice to the public, if used at all in food products offered for sale in North Dakota. In the light of the evidence presented and the conditions under which saccharin is being used in food products, I interpret the law as follows: THE USE OF SACCHARIN (COAL TAR SUGAR) SOMETIMES CALLED GARANTOSO, ARTIFICIAL SWEETENER, SYCOSE, GLUCID etc. IS PROHIBITED IN ALL FOOD PRODUCTS OFFERED FOR SALE IN NORTH DAKOTA.

We recognize that the courts must decide whether the above is the intent of the law. Whatever the final decision may be, we feel that the public are justified in refusing to purchase any food product containing saccharin, at least until the experiment by the National Government at Washington have shown the true physiological influence of this product. It is certain that the food products sweetened with saccharin cannot and do not possess the nutritive value of like foods sweetened with sugar.

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NORTH DAKOTA AGRICULTURAL COLLEGE.

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 58.

SOME STOCK POISONING PLANTS OF NORTH DAKOTA.

By L. VAN ES AND L. R. WALDRON.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
December, 1903.

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SOME STOCK POISONING PLANTS OF NORTH DAKOTA.

BY L. VAN ES AND L. R. WALDRON.

NOTE—Definitions of words not in every day use will be found defined on page 350.

There are a number of wild plants in this state, which have a poisonous effect after being eaten by stock. Besides those there are other weeds which are closely related to poisonous species, or cause poisoning only under certain circumstances. How great the losses are in this state cannot be told with certainty. Losses, however, do occur and it is the object of this publication to furnish information necessary not only for the prevention of plant poisoning, but also to enable stockmen to recognize the trouble, so that from them we may gather the required data in order to judge the extent of the trouble and the efficiency of prevention and treatment.

The different plants and the details observed in cases of poisoning will be taken up in order, but for the purpose of discussing some features of general importance a few remarks will have to be made.

While farm or range animals may at any time become poisoned by eating plants, which are found in hay or pastures, there are certain circumstances which seem to increase the danger. Poisonous weeds are always more readily eaten when other plants are scarce. When, in the early spring, certain poisonous plants make their appearance before the grazing plants, stock may be tempted to eat a quantity of them suffcient to prove fatal, which they would not do could they find an abundance of other food. The danger of driving sheep in close bunches through regions in which poisonous plants are found depends on the same principle. The foremost animals have a choice of food and confine themselves to grasses, while the ones coming behind in the bunch have to eat what the others have left and are consequently exposed to the danger of eating noxious plants. Hungry animals are more readily poisoned than others, as they are not so particular in the selection of the food they eat, and greedily take any plant within reach, while the poison is more readily absorbed. Chestnut and Wilcox call attention to the great danger of turning hungry animals which are unloaded from railroad cars on grazing grounds where poisonous plants are found.

Animals accustomed to a certain range usually avoid eating the dangerous plants peculiar to the region, while stock brought in from other sections may not be possesed of the same caution and eat a sufficient amount to prove fatal to them. Animals may become immune to certain poisons by daily eating small quantities of them very much on the same principle as that involved in people who contract a drug habit. A morphine fiend may eat a quantity many times the fatal dose for ordinary individuals.

The symptoms of plant poisoning vary according to the nature of the poison and will be discussed separately. The sudden illness or death of a number of animals at the same time should always lead one to inquire into the possibility of poisoning. There is a common belief among stockmen that poisoned animals always swell up before or after death. This phenomenon is common to a number of diseases and has no special value in the diagnosis of plant poisoning. The swelling is due to the formation of gas from the contents of an inactive digestive apparatus and which cannot be eliminated in the usual manner.

METHODS OF PREVENTION.

The prevention of stock poisoning is of the greatest importance. An apparently simple method to prevent poisoning by plants is to exterminate the plants. While this method may be practicable if the land be brought under cultivation, yet it becomes a difficult matter on an extensive area or where the land is not adapted for cultivation. Nearly all of our poisonous plants are easily subdued by cultivation. In many cases where native prairie meadows are cut for hay, it would probably be profitable from more than one standpoint to break the land and re-seed to Brome or some other good tame grass. A person cutting the tame grass would know the composition of it and feel confident that it could cause no harm in feeding. On the other hand there is always an element of uncertainty in feeding wild prairie hay. The farmer does not know what it may contain. In a more limited way the same principle will apply to pasturage.

But over a large portion of the range area, where grazing is of the greatest moment, it would be an injurious practice to break the land. The grasses and forage plants found growing there are the ones best adapted for that region and as a rule it would be a difficult matter to break the ground and establish a new turf and not have the Russian thistle occupy the land. It is not imposible, however, but that a grass may be found whih will be well adapted to the semi-arid regions and which can be introduced without difficulty. In such a case an area containing many loco weeds could be broken, the new grass introduced and the loco plants thus exterminated.

Efforts have been made to exterminate poisonous plants upon the range without breaking the land. In five years Colorado expended over $200,000 as bounty upon dried loco plants and while the plan was not entirely successful, yet enough was done to show that successful work might be accomplished along that line.

In Montana work was undertaken by a ranch owner, under the advice of the experiment station, to determine if the loco weed could be exterminated. The plants were cut off just below the crown over an area of four square miles during the months of May and June. This treatment killed out the loco and no losses resulted from loco poisoning the following season. The cost of the work was much less than the value of the stock lost in one season, before the loco was cut. Similar to mustard of the cultivated fields, the first years pulling gets the major portion of the weed. The second and third years digging of the loco weed would no doubt exterminate it.

Lupine is injurious when the seeds are ripening and during that time hay containing lupine should not be cut, or grazed from by inexperienced animals. Perennial lupine can be exterminated in a manner similar to loco weeds. The eradication of the annual lupine would probably be more of a task. The most practical way of dealing with lupine would be to keep the young and inexperienced sheep away from lupine areas. When the animal once has obtained a sufficient amount of poison, so as to show the effects of it, attempts should at once be made to counteract such effects in order to save its life.

ANTIDOTES.

The antidotes used in cases of plant poisoning may be divided into three classes.

One class spoken of as chemical antidotes act directly upon the poison in such a manner as to change its composition and render it harmless or prevent absorption into the system.

The second class, known as mechanical antidotes, either remove the poisons from the body or they form a coating around the harmful substance or even over the mucous membrane so as to prevent the absorption of the poison.

The third type of antidote has no action whatever on the poison but counteracts its effect on the body. A stimulant for example will counteract a poison which is depressing in its effects. Such antidotes are spoken of as physiological ones.

The action of our poisonous plants depends on the presence of substances commonly known as alkaloids and glycosides. While the action of those substances may show great differences, their chemical affinities show some similarity. Taking advantage of this, we are able to employ a chemical antidote which is useful in a number of cases of poisoning.

In permanganate of potash we have an agent which, by means of its strong oxidizing properties, has the power of destroying organic material. The active principles of the poisonous plants are included in those substances and are rendered inert when coming in contact with a permanganate of potash solution.

The action of this drug is entirely confined to the stomach or intestinal canal. When the poison once has become absorbed in the system the permanganate will not be able to come in direct contact with it and its action will be of no benefit. For this reason the permanganate of potash is most efficient as an antidote, when given at an early stage of the poisoning.

In the experiment of Chestnut and Wilcox it was found that the action of permanganate of potash was more prompt as an antidote when a salt known as sulphate of aluminum was given along with it. In the presence of this salt the non-poisonous contents of the stomach is less apt to cause the decomposition of the permanganate.

The dose of the antidote varies somewhat with the size of the animals but as a whole can be given as follows: 5-10 grains each of the permanganate of potash and the sulphate of aluminum to sheep; 15-20 grains to horses and from 30-50 grains to cattle. The substances must be given dissolved in water and special care should be used that the last bit of the drugs has been taken up by the water, as otherwise they may have an irritating effect. Clean water which does not contain too great amount of alkali may be used. In the smaller animals one-half pint of water and in the larger one one quart or more may be used per dose, in order to insure a rapid and thorough mixture with the contents of the stomach.

Stock owners whose animals are liable to become poisoned should always keep a supply of antidotes on hand. Those, however, must not be kept in solution as the permanganate has a tendency to deteriorate, when dissolved in water.

We recommend that a number of small paper boxes (pill boxes) be kept in readiness, each containing fifty grains of each permanganate of potash and sulphate of aluminum. Each box will be sufficient for five to ten head of sheep, two to four head of horses and one to two head of cattle. Those who own very large herds or flocks should keep larger quantities in the boxes. The boxes should be labeled so as to show the exact amount of the drug contained in it. The solution is best given as a drench. In animals which have lost the power of swallowing the antidote may be injected directly into the stomach by means of a canula, which is introduced in the same manner as in cases of bloat. In such animals it would be dangerous to force the drench down the throat as the fluid is apt to enter the windpipe and strangle the animal, or cause an inflammation of the lungs.

Mechanical antidotes have only a very limited use in cases of plant poisoning of our farm or range stock. Vomiting cannot be promptly induced, usually not at all and the length of the intestinal canal renders the elimination of its contents by means of a purgative, entirely too tedious a process.

Some stockmen give oil or melted lard in cases of poisoning. This may be beneficial by retarding the absorption of the poison because the lining of the intestinal walls as well as the plant particles, are coated by a greasy layer. Such treatment, however, is not to be depended upon.

The physiological antidotes vary according to the poison taken or the effects produced by it. Poisons with a depressing action on the important organs have stimulants as their antidote. Whiskey, aromatic spirits of ammonia, strychnine, digitalis and atropine are representatives of this class. Poisonous substances which have an exciting action are counteracted by sedatives such as morphine, chloroform, or chloral hydrate.

When speaking of special poisonous plants those physiological antidotes will be more fully discused.

WATER HEMLOCK *(Cicuta maculata.)*

This plant is also commonly called cowbane, spotted cowbane, spotted beaver poison, spotted parsley, children's bane and musquash root. It is a smooth perennial growing each year from three to ten fleshy, tapering roots from three to five inches long and about one-half inch in diameter. Among these are mixed some slender fibrous roots. The stem is rather stout, hollow, three to six feet high, streaked and spotted with reddish purple. The

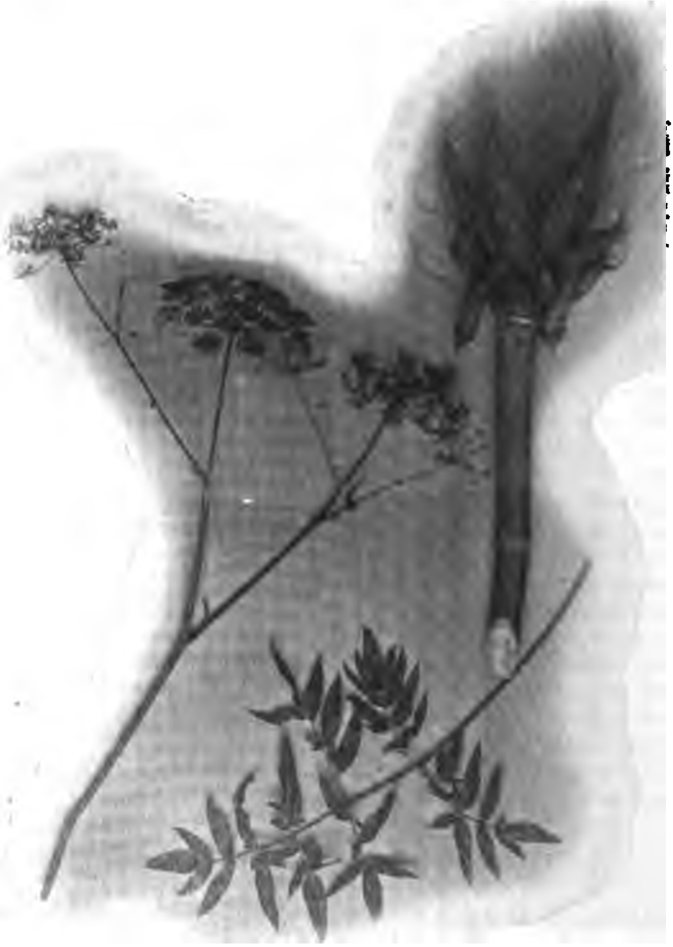


PLATE I—Water Hemlock (*Cicuta*). Note the leaf and the fleshy root About ¼ size. (Original.)

leaves are doubly compound, that is, each leaf is made up of many leaflets, each one appearing like an individual leaf. The leaves are arranged as shown in Plate I. The small white flowers are arranged in several flat topped clusters, called umbels resembling the flower clusters of the garden parsnip. A reference to Plate I, which is from the photograph of the plant shows the characters enumerated above. It is found throughout the state in wet places, in coulees and along river banks.

Although the distribution of water hemlock is general, yet locally it is more abundant in some localities than others. For instance, it is very abundant in the hav meadows along the Souris river near Towner, but found only occasionally at Barton, northeast of Towner. It is said to be particularly abundant in various places in Emmons County.

A plant, water parsnip, so closelv resembles the water hemlock that it will be well to describe it also. It is commonly mistaken for water hemlock, but is said by good authorities to be quite harmless.

Water parsnip, *(Sium cicutae folium, Pl. II.)* is a smooth perennial growing each year from a number of fibrous roots which rarely exceed a diameter of one-sixteenth of an inch. The stem is hollow, very stout towards the base, three to six feet high, and green. The laves are compound but *simply pinnate*, that is, the leaflets are arranged in pairs along a main axis similar to those shown in Plate II. The fruit is smaller and more ribbed. The parts to be noticed in distinguishing the water parsnip from the water hemlock are the *leaves* and *roots*. By reference to the cuts it is seen that the leaves and roots show marked differences and, by these, the two plants may always be distinguished. The roots of the water hemlock in young plants are sometimes apparently fibrous, but they are scarcely ever smaller than a lead pencil and always larger than the roots of the water parsnip. Basing our knowledge upon the plants sent in, other plants besides the two above mentioned are seldom taken for the water hemlock. Both plants may be in one coulee, and it is not safe to conclude that no water hemlock is present if two or three of the plants prove to be water parsnip.

The only means of eradication that can be recommended is to pull or dig the entire plant, including al the roots, pile them where they cannot be molested by stock, and when dry, burn.

Wild parsnip, *(Pastinaca sativa,)* the common garden parsnip run wild is commonly supposed to be poisonous, but the work

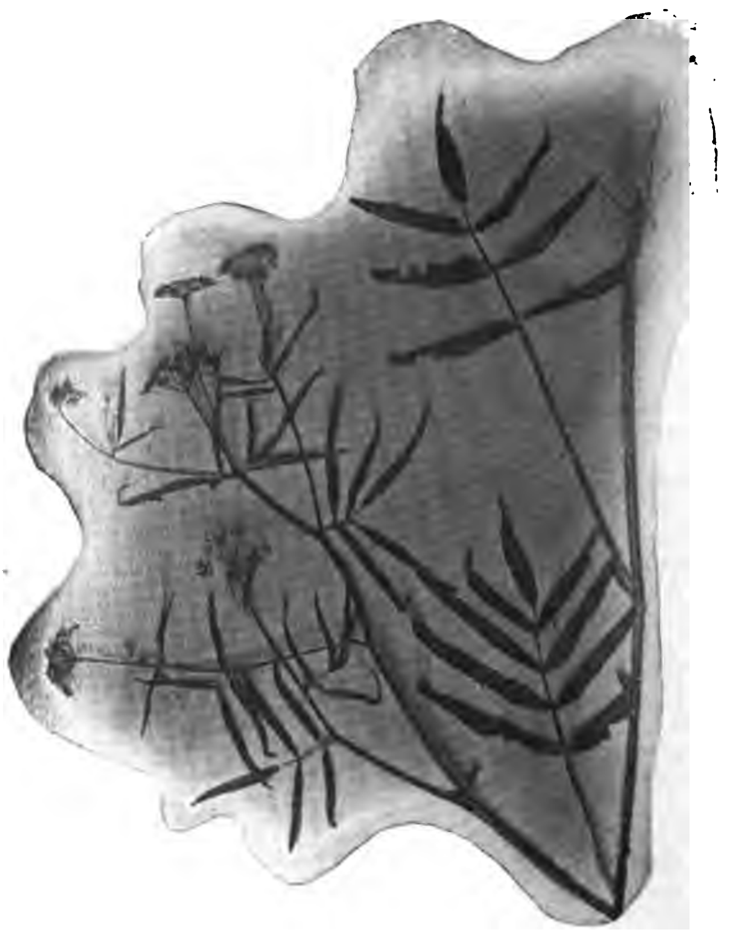


Plate II.—Water Parsnip. (*Sium*,) Not poisonous. Notice the simply pinnate leaf and the fibrous root. About ¼ size. (Original)

done by Prefessor Pammel upon this plant in Iowa shows quite conclusively that the plant is quite harmless as studied there.

In dealing with the Cicuta species, all parts of the plants must be considered as dangerous to stock.

The poisonous properties of the roots are well known, while the stems, leaves and seeds have also proven to be dangerous. Most cases of poisoning by hemlock are perhaps due to the green plants, but the losses due to the eating of contaminated hay are also considerable.

Some months ago this station was consulted by an owner of sheep, who complained that his sheep were dying of some disease and who wished to be instructed as to the measures to be taken. As the symptoms described were those of poisoning no investigation was made on the spot, but as a preliminary measure our correspondent was instructed to make a collection of the weeds found in the hay which he was then feeding to his sheep. The weeds were promptly sent in and the most conspicuous one among them was water hemlock. The party owning the sheep later on informed us that he had not lost any sheep since he had ceased using the hay from the contaminated stack. This little experience tends to show that the dried plant is by no means harmless.

Owing to the large amount of poison contained in the *root*, this part is the most dangerous to stock. As long as the soil is hard and firm, the danger of poisoning by means of the root is slight, but as soon as the ground is softened by moisture, grazing animals readily pull up the roots, which by their fleshy structure and somewhat sweet taste are seldom rejected by a hungry animal.

Cases of poisoning are on record produced by animals grinding with their feet, roots of hemlock, growing in pools or coulees, and later on, drinking the water, which had dissolved enough poison from the mashed roots to give rise to fatal intoxications.

The poisonous principle of the Cicuta species, (cicutoxine,) is extremely virulent and small amounts of the plants have been eaten by stock with fatal results.

Professor Hedrick of the Oregon station reports that a piece of the root the size of a walnut was sufficient to kill a cow.

Symptoms: The first symptoms which present themselves are a twitching of the muscles, watery eyes and an increased body temperature.

In some animals great distress and excitement are observed; this is especially the case in sheep, which show cerebral frenzy and severe pain. Poisoned sheep will blindly run away from the flock until overtaken by the fatal spasms. In cattle and horses severe muscular spasms are a prominent symptom. Breathing is often hurried and irregular and seems to be carried on with difficulty. Poisoned animals froth from the mouth, while in most cases there is an increase in the amount of urine. A distinguishing feature of hemlock poisoning is the rapiditv with which the symptoms develop. Animals often die within one hour after eating the poison.

POST-MORTEM APPEARANCES: On opening the cadaver the tell-tale odor of the plant may be noticed. The lungs are usually congested, death being due in the majority of cases to asphyxia, owing to the spasm of the muscles controlling the respiratory movements. Inflammatory conditions are frequently found in the mucous membrane of the stomach. In the contents of the stomach, parts of the plant may be identified. Cerebral congestion and edema have often been observed.

PROGNOSIS: When an animal has taken such a quantity of hemlock as will give rise to symptoms, the prospects for the patient are decidedly unfavorable. The development of the more severe symptoms is usually so rapid that treatment will be too late.

TREATMENT: Permanganate of potash, given as indicated above, should at once be administered with a view of rendering any unabsorbed poison harmless. The symptoms should be met by physiological antidotes. The more prominent ones which are indicated in this class of cases are morphine and chloral hydrate.

Morphine can be most rapidly administered and should be preferred when a large number of animals are poisoned. It is best given by means of the hypodermic syringe. The dose for horses and cattle is from three to eight grains and for sheep from one-half to one and one-half grains, according to the size and age of animals and severity of symptoms. Chloral hydrate may be given by the mouth or by the rectum, but in all cases must be completely dissolved in water in a proportion of at least one to twenty, as chloral hydrate will otherwise have an irritating effect. Horses and cattle take from one and one-third to two and one-half ounces and sheep from one to three drachms.

While the animals are being treated they should be in a quiet place and all undue excitement must be avoided.

LARKSPUR.

CAROLINA LARKSPUR *(Delphinum Carolinianum, Pl. III,)* is the only one yet collected in North Dakota. There is no direct evidence of its poisonous nature, but as practically all the remaining species of larkspur are poisonous, it is probable that this also may be considered toxic in its effects. It is a prairie plant. It grows one to two feet in height from a perennial root. The leaves are deeply divided into oblong or linear lobes and these again have broadly spreading lobes. The flowers form a long, narrow, spikelike raceme terminating the stalk. They are three-fourths of an inch long, vary from light blue to nearly white in color and are characterized by possessing a long conical spur, which lies horizontally or is tilted upwards. The pods are one inch long, lie close to the stem and are deeply three pronged. (See Plate III.) The seeds are rough and angled. The pods resemble those of the common wild columbine, but the flowers of the latter are red with yellow inside and the plant grows in woodlands. The plant is more or less common in Grand Forks, Traill, Cass, Richland, Ransom, Barnes, Steele and Stutsman Counties, but is not known to occur further west. The plant blossoms in June and July, but the leaves start quite early in spring and it is at this time that the larkspur is dangerous to stock.

The leaves are the part of the larkspur species which cause the most cases of poisoning. The roots while containing the poisonous substance characteristic of the plant are woody and are not so apt to be eaten. The young plants seem to be the most toxic and as larkspur with its succulent leaves makes its appearance quite early in the spring, they constitute a special source of danger. Late falls of snow will cover up the forage plants and leave the young larkspurs protruding. Under such circumstances grazing animals are apt to eat a fatal quantity. In older plants the toxic principle seems to be present in a smaller percentage.

SYMPTOMS: Poisoned animals show a stiff, irregular, straddling gait. Twitching and involuntary movements of the muscles are seen. These movements change to spasms in the later stages of the poisoning. Sheep often become so stiff that they fall to the ground. There are attempts at vomiting, regurgitation of gas and food takes place and the animals froth from the mouth. The animals are easily excited, but when kept quiet they will show a fair appetite until nearly dead. In the early stages the temperature and the pulse rate becomes somewhat lower. Breath-

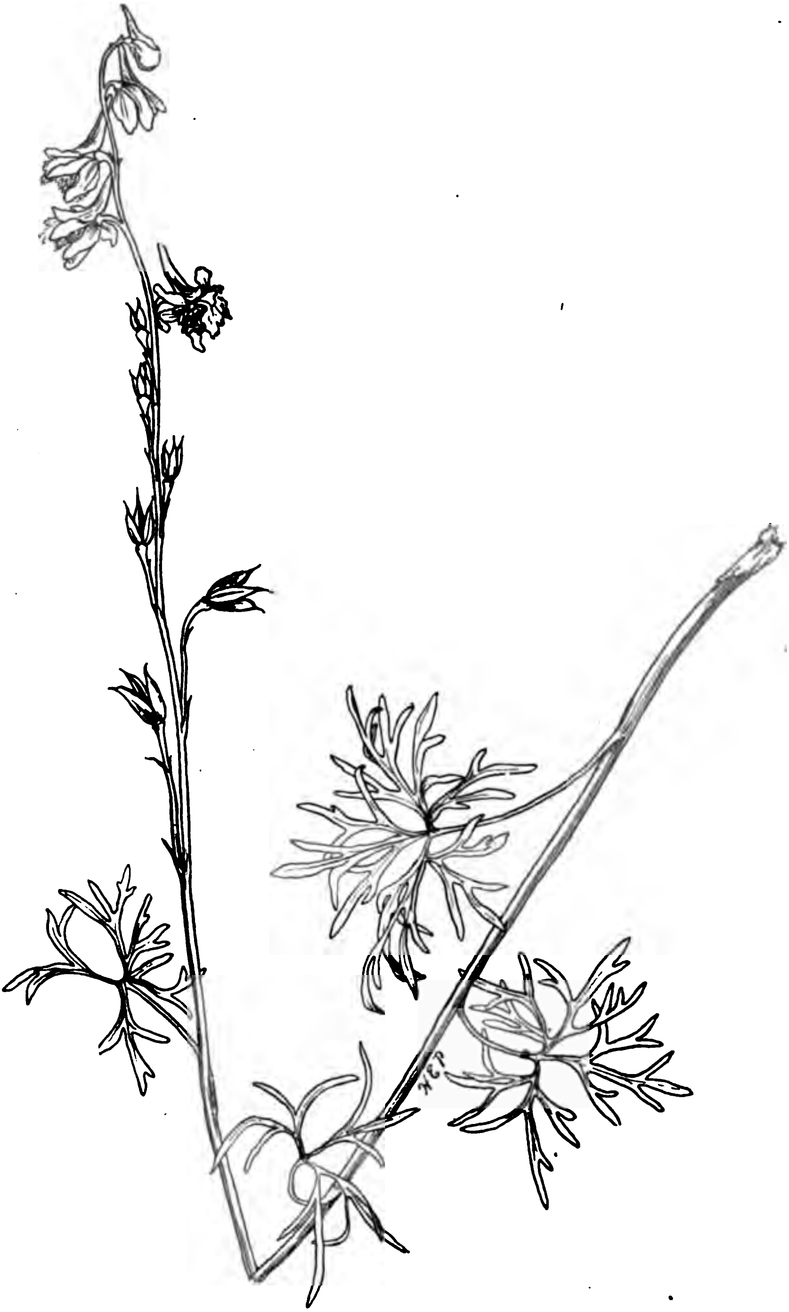


Plate III.—Carolina Larkspur. About ½ size. (Original.)

ing frequently is very rapid and shallow. Death is always preceded by violent spasms.

Post-mortem appearances: Death from larkspur poisoning is probably directly due to paralysis of the respiratory centers and the post-mortem apearance is that peculiar to cases dead with asphyxia. The veins and right side of the heart are distended with blood while the lungs are congested and tinged with blood. The digestive organs show nothing abnormal. The brain, liver, spleen and kidneys are unchanged to the naked eye with the exception of the overfilling of the veins.

Prognosis: The forecast in cases of larkspur poisoning depends on the quantity taken, the treatment of the symptoms and on the time when the permanganate was given as an antidote. A large amount of plants taken, and subsequent severe symptoms of poisoning, makes the prognosis somewhat doubtful. The outlook in such cases, however, becomes more hopeful when an early administration of the permanganate of potash drench is possible.

Treatment: In poisoning from this plant the permanganate of potash and sulphate of aluminum can be used with fair chances of success, as the poison is slower in its action than in hemlock poisoning. The sooner the remedy is applied, however, the better. When the muscular spasms are pronounced, some morphine may be given. Chestnut and Wilcox recommend the hypodermic application of atropine in doses of one-half to one grain for cattle and horses. Alcohol (whiskey) one to two ounces to horses and cattle, one-half ounce to sheep, and aromatic spirits of ammonia (one to two ounces to horses and cattle, two to four drachms to sheep, in cold water,) is of value when the breathing becomes shallow and weakness a prominent symptom.

LOCO WEEDS.

(Aragallus Lamberti, Aragallus splendens.)

The loco plants of the state number at least two with possibly one or two more. The more common one *(Aragallus Lamberti Pl. IV,)* is known as crazy weed and loco vetch.

The plant grows from six to ten inches high, in tufts or bunches from a perennial root. Leaves and flower stalks are not strictly erect, but are somewhat ascending; they arise from near the ground so the plant is apparently stemless. The leaves are pinnately compound; the leaflets, numbering about fourteen, are

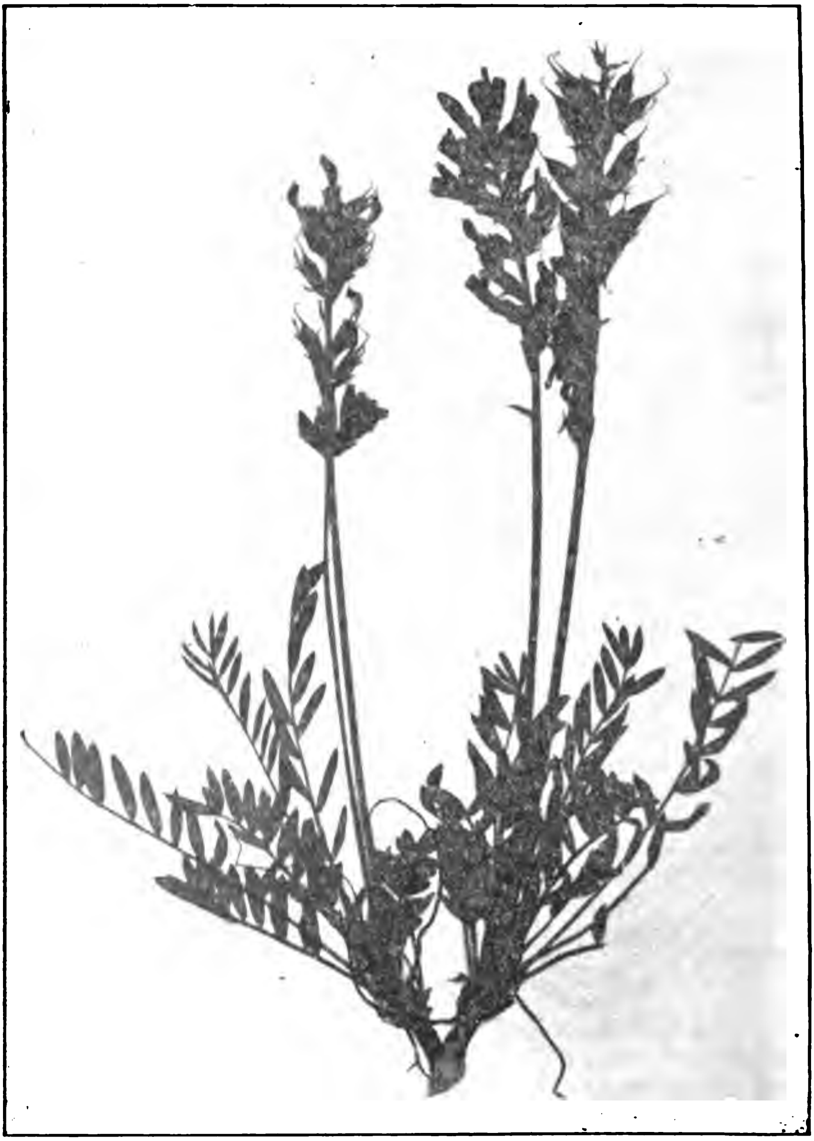


Plate IV.—Loco Weed. (*Aragallus Lamberti.*) About ½ size. (From a photo by Prof. Keene.)

arranged in pairs along a common axis. The flowers are purple or purplish and are arranged in more or less compact clusters at the ends of the flowering stalks. The whole plant is whitish, due to the woolly hairs that cover it. It blossoms in June and July. Crazy weed is found growing on the open prairie and is a typical prairie plant. The plant has been found in Cass, Grand Forks, Ramsey, Barnes, Stutsman, Morton, Ward and Billings Counties. The plant is generally distributed in North Dakota. Very little complaint of this plant has been brought to our notice. This is probably due in part to the ranges not being greatly exhausted as they are in other states. The grass is more abundant and animals are not forced to eat non-nutritious or poisonous plants. The most important loco weed in Montana is closely alied to this one, but has white flowers. It does a large amount of damage and it is possibly due to the more attractive nature of the white flowers, in comparison to the purple ones of the North Dakota plant. The North Dakota loco plant is undoubtedly as abundant in places in North Dakota as other loco plants are in other states and we may expect loco poisoning under favorable conditions.

The showy loco weed, (Aragallus splendens) is very similar to the preceding except that it is more silvery in color, due to the great abundance of white hairs, and the leaflets ocur, three, four or even five together on the leaf stalk; Plate IV. The plant forms broad tufts or bunches, a foot or more across. These silvery bunches, bearing racemes of rich purple flowers form striking objects on the prarie during the early part of July. The plant prefers more sterile soil than the other loco weed. This plant has been reported only from Grand Forks, Pierce, Towner and Ramsey Counties. It probably has a wider distribution. In the counties where found it has not been found abundant enough to cause any extensive loco poisoning.

There are few stockmen on our western ranges who are not familiar with the peculiar phenomena exhibited by animals which are poisoned by this group of weeds. The name "loco" is taken from the Spanish and means crazy, and if one hears the subject of "locoed" horses or sheep and their performances discussed by cowboys, he would consider the name well chosen. As will be seen later, the animals are really suffering from hallucinations and are apt to give evidence of those by the strangest actions.

Loco poisoning is produced by the eating of the leaves, stems, flowers and fruit of the species mentioned. The active principle of the plant, however, is unknown and its presence can only be surmised by its specific action on animals.

While acute cases of poisoning occur, the greatest harm is done by chronic intoxication. When through scarcity of food or through a depraved condition of the stomach, an animal eats a large quantity of loco weed, acute poisoning may occur. Such cases are, however, rare and animals will usually have to cultivate a taste for the plant, before they eat large quantities of it. Most range animals dislike the plant, but there are certain conditions which seem to overcome this normal disinclination. When animals once acquire a taste for the loco species. their appetite for them assumes a morbid character and the condition in this respect is the same as in man in the case of morphine, cocaine, arsenic or other drugs. An animal which has once become a loco-fiend will refuse any other food, but will eat extraordinary quantities of its favorite weed. The predisposing factors are: 1st, a perverted appetite; 2nd, a suggestion or example given by confirmed loco-eaters.

A perverted or morbid appetite is sometimes acquired by animals when food and water are scarce and when they cannot get the supply of salt, which is required for the normal performance of the functions of the body. Animals, especially sheep, which have been deprived of salt for a long time, will sometimes eat substances which they otherwise would not touch. Alkali, earth weeds, etc., are taken in such cases and this has given rise to a belief among stockmen, that "loco" is produced by the eating of alkali. This view, however, is erroneous, as the same abnormal condition of the digestive apparatus, which induces animals to eat alkali soil, causes them to eat noxious and ill-tasting plants like the loco-weeds.

The second factor instrumental in producing loco-fiends among animals is that of suggestion. It is a matter of observation by many stockmen, that loco-disease was unknown in a herd or flock until after the introduction of some locoed animal. This animal teaches the others to eat the plant. This phenomena is also seen in other instances. Some of the vices of the horse are often acquired by intuition, viz.: cribbing or windsucking and weaving. After a few animals once have acquired the habit, it rapidly spreads through the whole herd. When devising means of prevention, those facts must be borne in mind. Cattle are less apt to become poisoned by loco than horses or sheep, although by no means exempt.

SYMPTOMS: In active or acute cases of poisoning the animals present symptoms indicating that the poison is most active on the central nervous system. There is an aimless walking around long or short circles, the animals always turning to the right or left, but apparently unable to do the opposite. The movements are inco-ordinate. Blindness from a central origin is observed. There is champing of the jaws and frothing from the mouth. Attacks of this sort may pass off, leaving the animals in a stupid condition, but finally they will rapidly succeed one another, while convulsions make their appearance.

Some animals, (sheep,) will push their heads firmly against objects and stand in that position for hours, or until convulsions cause them to fall.

In a case of acute loco-poisoning observed by Chestnut and Wilcox, it was noted that the milk conveys the poisonous principle of the plant. A suckling lamb of a poisoned ewe even died before its mother, presenting the same characteristic symptoms. While the symptoms of cases of acute poisoning are of sufficient importance to be described, the majority of the intoxications present themselves under the chronic form.

The phenomena presented are those of severe mental aberration. The animals seem frequently to have lost the power of interpreting properly the impressions coming through the organs of special sense. A horse may show fear of any object, which has been familiar to him for years. Sometimes all comprehension of size has been lost and animals, which when well, step over a post or piece of rope, will, when locoed, do this with the effort necesseary for a five foot hurdle.

The power of vision or hearing is often impaired, or the impressions received by these senses are frequently perverted. An animal may seemingly be deaf to the report of a gun, while a slight noise may startle it greatly.

Locoed horses which are being used for work sometimes without any cause will kick or run away. While those symptoms are usually present in all stages of the poisoning, they are augmented in the later stages by severe muscular weakness, trembling and emaciation. The latter is particularly due to the lack of nutritious food. A confirmed loco-eater will not take any food except the loco-weed, as long as it can possibly get a supply of it, and will sometimes go for a long time even without water. It is difficult to keep locoed sheep in a herd, as they will constantly wander away in search of their favorite weed.

POST-MORTEM APPEARANCES: The appearance of the internal organs of animals dead with loco poison is not a typical one. In chronic cases the picture is one of emaciation, owing to the long continued mal-nutrition to which the animal was exposed. When death resulted from convulsions, we have often found congestion of the lungs and an enlargement of the right heart and nervous symptoms.

In the digestive organs, intact or partially digested loco-plants may be found and this would be the best post-mortem evidence as to the nature of the case.

In Bulletin 35 of the Kansas Experiment Station, some marked brain lesions are described in connection with loco-poisoning in cattle. The changes here described are those of degeneration of the cerebral and cerebellar cortex, and a thickening and congestion of the covering membranes.

PROGNOSIS: In confirmed loco-eaters of long standing, showing emaciation and marked hallucination the prognosis is bad, as even an enforced healthful diet will not set things right.

Cases which contracted the habit more recently, when kept away from the weed and well fed will usually come out all right. This is especially the case in sheep. Those animals soon return to their natural feed when access to loco is prevented and will respond to intelligent care in a profitable manner.

TREATMENT: In cases of acute poisoning the permanganate of potassium and sulphate of aluminum treatment is indicated in the beginning. Morphine will here be found useful as an antispasmodic.

In chronic and confirmed cases, medicinal treatment is of no value, perhaps with the exception of such remedies as have some influence on the action of the stomach, such as common salt, dilute hydrochloric acid or gentian root. Such cases may be successfully managed by keeping them off the range or pasture and feeding them on good wholesome food in corrals. Locoed sheep may in this way be prepared for market. When animals are successfully treated in this manner, it is not prudent to turn them on the loco-infected range again, as they are very apt to go back to their old habits. They should be cared for on other ranges, or in the case of horses, be kept in corrals or stables.

Preventative measures in connection with loco are of the greatest importance. In practicing this prevention, two points must be borne in mind, first, animals which receive good wholesome food and an abundance of salt are not apt to become loco-eaters. Stockmen should especially attend to the salting of their animals, as salt is a substance that no animal can dispense with and thrive. Second, the first animal in a herd or flock, which commences the eating of loco-weed, should immediately be taken from the range, as other animals will soon imitate the habit. This is a matter of some importance and should not be overlooked on ranges on which the loco-weed is found.

DEATH CAMAS *(Zygadenus venenosus Pl. V.)*

This plant is known in more western states by various names such as wild leek, wild onion, sego lily, mystery grass, etc. It is not an onion, though belonging to the same family as the onion, the lily family. It is perennial, growing to a height of one to two feet each year from an underground, scaly, onion-like bulb about one inch long. The true fibrous roots penetrate from the base of the bulb more deeply into the ground. The somewhat fleshy leaves are linear, being long and narrow. They arise from near the ground. The leaves resemble grass leaves somewhat, and the plant would no doubt be taken for a grass by many, before flowering. The rather small, yellowish-white flowers, numbering thirty or more are borne at the top of the stem in a compact racemose cluster. The flowers are lily-like in structure. The number of petals is six. Plate V illustrates the plant. The plant blossoms in June and early July and soon after the seed ripens the plant dies. The plant is dangerous to stock in the early part of the season when the foliage is green.

Death camas has been found in Williams County and in parts of Ward County, in North Dakota. It will probably be found to have a wider distribution in the western part of the state. It is found also in South Dakota and over the entire state of Montana. The plant starts to grow early in the spring, and where the plant is abundant, the succulent leaves are probably inviting to hungry stock. The plant is found in drier areas than the swamp cases but it does not prefer the driest situation.

No cases of poisoning by this plant have come under the observation of the writers in this state, but as the plant occurs abundantly in certain parts, it deserves the attention of stock growers and ranchmen. The effects of death camas, as a plant dangerous to stock have been studied by Chestnut and Wilcox in the state of Montana, where annually a large number of sheep die from eating this plant.

From these experiments it seems that all parts of the plant are poisonous. When the ground is dry the bulbs cannot be pulled out, but when the soil is thoroughly soaked, this can be accomplished in many cases. They estimate the death rate in poisoned animals to range between 5 and 48 per cent.

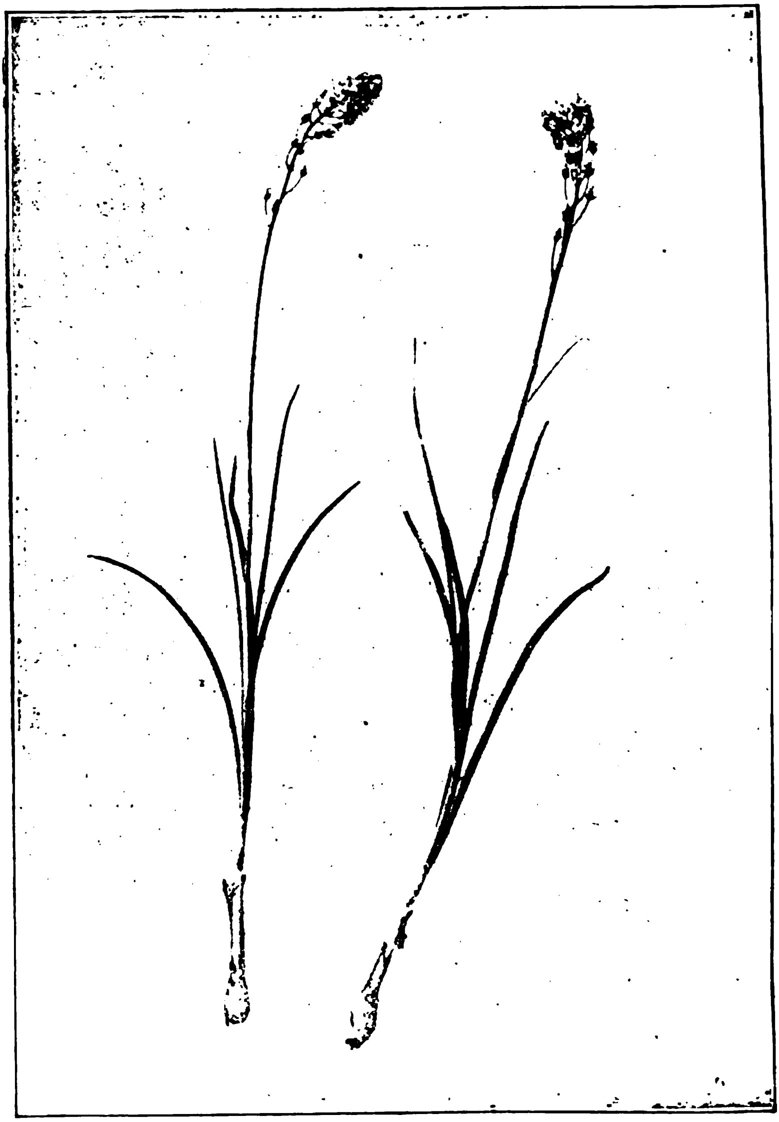


PLATE V.—Death Camas. (*Zygadenus venenosus.*) **About ⅓ size.**
(After Chestnut, Dept. Agr.)

Symptoms: Uneasiness and irregularity of the muscular movements are the earlier signs of camas poisoning. Later on the respiration becomes hurried and incoordination of movements is observed. Chestnut and Wilcox found, that, while the patients are highly excited and subject to convulsions, cerebral symptoms seldom assumes the character of frenzy.

The severity of the symptoms is, like those in most intoxications, in proportion to the amount of poison taken. The above-mentioned authors, however, found that in some cases of poisoning in sheep, the animals pass through the earlier symptoms slowly and become helpless after ten or twelve hours, remaining in a condition of paralysis for 24 to 48 hours. They further observed that animals which were in this condition for a certain length of time rarely recovered. Salivation is increased and regurgitation of gas and food stuffs through mouth and nostrils is an almost constant symptom. In lambs belonging to poisoned ewes similar symptoms were observed; in addition there were signs of a severe gastro-intestinal disturbance.

Post-mortem appearances are very similar to those found in animals poisoned by larkspur and are sufficiently characteristic to be used as a base for post-mortem diagnosis.

Prognosis: This depends largely on the stage of poisoning, when treatment is begun and on the amount of poison taken. When the antidote is given at an early stage the prognosis is rather unfavorable.

Treatment: The permanganate of potash and sulphate of aluminum treatment as described at another place is the most reliable one in cases of camas poison and need not be described in detail at this place.

SWAMP CAMAS, GLAUCOUS ZYGADENUS.

(Zygadenus elegans, Pl. VI.)

Swamp camas is a perennial plant growing from underground, onion-like bulbs to the height of two feet. The leaves are bluish, few, arise mostly from near the base and are narrow and fleshy, resembling grass leaves to some extent. The flowers are numerous, yellowish, one-half inch in diameter and aggregated into an open panicle. (See Plate VI.) The plant commences flowering about June 10th and continues blossoming into July. By the last of July the plant is nearly mature, the seeds are ripe, the stalk is dry and the leaves yellowish. The seeds are nearly 3-16 of an inch long, 1-16 of an inch wide, yellowish, flattened and somewhat twisted. The seed coat is wrinkled, thus giving it a winged effect

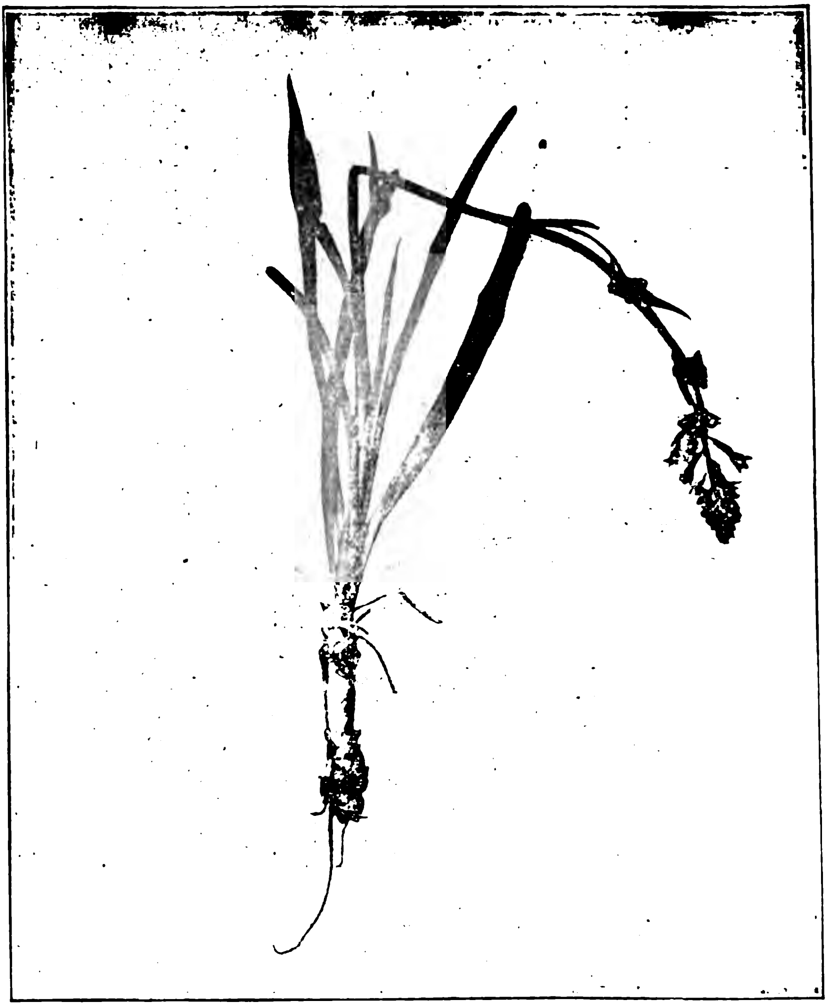


PLATE VI.—Swamp Camas. (*Zygadenus elegans.*) About ¼ size.
(After Chestnut, Dept. Agr.)

and also makes the seed appear as if immature. As the seeds are light, the wind aids in their distribution. The bulb is scaly, white, one inch or less in diameter at the base, tapering gradually to the stem. Swamp camas is found growing in rather wet places on the prairie and along the edges of shallow coulees. In a depression of the prairie it would be more apt to be found along the sides of the depression than at the bottom. It is generally abundant where found and in the early part of July forms quite a striking picture and the plant can be readily distinguished from the car window. The plant is quite generally distributed over the state. It has been collected in Cass, Barnes, Stutsman, Sargent, Grand Forks, Pembina and Ward Counties. It has been observed along the main line of the Great Northern road as far west as the Montana line and it has also been seen in many other portions of the state.

ERADICATION.

If the tuber of the swamp camas is dug out, the plant will not grow again. Ordinarily there are not so many plants upon a section, or half-section, but what they could be exterminated with a reasonable outlay by individual digging. If the plants are quite abundant over many acres, the best method would be to break the land and reseed to tame grasses such as brome grass. The plants will not reappear after the land is once broken, at least for a number of years.

This species is closely allied to the preceding one and while its poisonous properties are not definitely known, some observations were made which should cause the plant to be regarded with a great deal of suspicion.

Chestnut and Wilcox report that hay containing this weed was poisonous to sheep and that six cattle were poisoned while grazing in a pasture where it grew abundantly. The symptoms of the sick cattle and the post-mortem appearances of those dead with the poison were similar to those observed in cases of death camas poisoning.

The following case, supporting the suspected character of the plant came to the notice of the writers.

A resident of Walsh County reported in March that since late in the preceding fall he had lost 16 head of cattle. The symptoms described were very vague and did not point to any special lesion. The animals showed considerable suffering and died after a few hours' ilness. A post-mortem examination was made on an animal, dead for 24 hours. Nothing, permitting of a definite diagnosis, was found. The congested condition of the venous system and right heart seemed to indicate death by asphyxia. The lungs were also congested. The contents of the stomach did not contain parts of the plant in proper shape for identification, but in a collection of weeds made from the hay, which was eaten by the animanls, numerous stems and dried fruits of ***Zygadenus elegans*** were found A substance obtained by the evaporation of an ether extract made from the acidulated stomach contents produced some marked toxic symptoms on hypodermic injection into a rabbit. Five minutes after the injection, the animal appeared to be stupid, in ten minutes the breathing became rapid and the animal dragged its hind quarters; 20 minutes after the dose was given, a slight convulsion occurred. After thirty minutes the animal dragged itself about, but the breathing is somewhat slower. After three hours the rabbit was able to assume its normal posture but with some difficulty. After six hours the animal has apparently recovered.

Some experiments were made by the writers in order to study the effect of the plant on rabbits, but owing to the fact that only a small quantity of the plants was available, they could not be carried to a definite conclusion. Those experiments included some feeding experiments and the hypodermic injection of substances obtained by the Otto-Stass alkaloid extraction method. Rabbit No. 1; 5 grammes of the bulb offered. At 12 m. about 0.5 g. was eaten. At 1:30 p. m. the whole quantity was consumed, but with reluctance. The rabbit was watched until 6 p. m. but no toxic symptoms made their appearance.

Rabbit No. 2. Forty grammes of dried plants were offered and consumed in two hours. No effect followed the eating of the plants.

Rabbit No. 3. Received hypodermically 0.04 g. of substance extracted with chloroform, but did not suffer any bad effects.

Rabbit No. 4. Received subcutaneously 0.03 g. of substance obtained by ether extraction from alkaline extract of plant. Injection made at 3 p. m. At 3:30 slight incoordination of movements. At 3:45 the same one continued and when the animal is excited by blowing upon it,it has a slight convulsion. At 4:30 rabbit fell upon its back and is not able to resume its normal posture without aid. The intoxication is very marked. At 5:30 the rabbit is very stupid and its breathing shollow. The following morning the animal is apparently very sick and at 2 p. m. it died. Weight of rabbit 490 g.

The lesions shown on post-mortem are such that death by sepsis cannot be excluded. The symptoms of the preceding day were undoubtedly due to the injection of the toxic material.

Rabbit No. 5. Received hypodermically 0.01 g. of substance obtained by chloroform extraction of acidulated extract of plants. Some transitory dullness resulted, but in three hours the rabbit was apparently all right.

Rabbit No. 6. Subcutaneous injection of 0.02 g. of material obtained by the extraction of acidulated extract of plant. This caused the animal to droop in a corner of the cage for a few hours, but produced no results otherwise.

Rabbit No. 7. 10 c. c. of watery extract was introduced into the stomach by means of rubber tube. No toxic symptoms developed.

Rabbit No. 8. 15 c. c. were given in the same manner as in No. 7. No evidence of poisoning was observed.

The results of those experiments are not conclusive but indicate that Zygadenus elegans, swamp camas, contains a principle toxic for rabbits, although those animals are not readily poisoned when the substance is taken by the stomach. The subject will be studied more fully during the coming season.

The symptoms of swamp camas poisoning, as far as our present knowledge goes are similar to those produced by Zygadenus venenosus.

The permanganate of potash and sulphate of aluminum treatment is also here indicated.

LUPINES.

The lupines known at the present time in North Dakota are two in number. The silvery lupine (Lupinus argenteus) has been found near Medora in the Bad Lands and at the mouth of the Cannon Ball River. They will undoubtedly be found to have a wider distribution when the ground is more thoroughly worked. The lupines, like the loco-weeds, belong to the pulse or clover family. They have a general resemblance to the loco-weeds, especially in the flowers and fruit. The low lupine (Lupinus pusillus) has been reported from Medora and south of Bismarck.

Silvery lupine is a bushy branched perennial, somewhat shrubby, one to two feet high, silvery in appearance by its fine and densely hairy covering. The leaves differ markedly from those of a loco-weed. They are compound but the leaflets, to the number of five or more, radiate from the end of the leaf stalk forming a partial circle when the leaf is spread out, about two inches in diameter. The flowers are blue, about one-half inch long, somewhat crowded on terminal racemes three or more inches in length. The pods are about one inch long, three to five seeded and covered with many brown silky hairs. The seeds are whitish and flattened. The low lupine is an annual, not exceeding a height of more than eight inches. The leaves resemble those of the silvery lupine. The flowers are blue, on short, densely-flowered racemes, which either terminate the branches or are lateral. The pods are three-quarters of an inch long, densely hairy and two-seeded.

The well known Indian turnip *(Psoralea esculenta)* of the prairies, has a leaf resembling the lupine leaf but it can be told by its large, starchy, tuber-like root. Indian turnip is distributed over the state.

Lupines are readily eaten by cattle and horses, more sparingly by sheep. In some sections of the country the plants are used largely for forage purposes as the poisonous nature of the plants seems to be dependent only upon certain conditions. The pods of the lupines, the more poisonous portion, are ripe in July and hay containing lupine cut at that time is very dangerous to feed.

Frohner in his "Lehrbuch der Ioxikologie" observes that lupine poisoning only occurs in certain regions and at certain times and mentions the possibility of the poisonous principle of the plant (lupinotoxin) being the metabolic product of certain moulds, which occur on lupine as parasites.

Chestnut and Wilcox, who studied the subject in Montana, lay stress on the fact that the pods and seeds are the most dangerous to stock. Lupine hay made after the seed has fallen from the pods is regarded as less dangerous than hay cut earlier in the season, when the seeds are gathered with the hay.

SYMPTOMS: In this country only the acute type of lupine poisoning occurs. The most prominent symptom in poisoned animals is mental excitement. The animals, especially sheep, will blindly run in different directions colliding wildly with one another and with various objects. These symptoms gradually make way for one of severe convulsions, falling fits, irregularity of movements, and a final collapse. In this condition the animal is no longer able to keep on its feet and suffers from frequent convulsions, simulating those seen in strychnine poisoning.

In animals which do not eat a fatal quantity, the same type of symptoms are observed, but they are less severe and extend over a longer space of time.

In the chronic type of poisoning, known to European observers under the name of lupinosis, the symptoms are those of fatty degeneration of the glandular organs (liver and kidneys) and the heart. There is loss of appetite, fever and in course of time the visible mucous membranes are found to be jaundiced. These phenomena are accompanied by dullness, excitability, trismus and paralytic conditions, constipation and loss of weight. The animals succumb in course of time in a condition of pronounced emaciation.

The chronic type of poison has, thus far, not been observed by American authors, but it is quite possible that the conditions occurs in sections where the plant is used for feeding purposes and that owing to its longer duration, poisoning was not suspected.

POST-MORTEM APPEARANCES: Autopsy discloses congestion of the brain and of the lungs, while the kidneys and liver show the signs of degeneration. The nervous system is frequently found to be engorged with blood. The lesions produced by the poison are not typical and are not a reliable guide for diagnosis.

The contents of the stomach, however, may contain the seeds in a fit condition for identification.

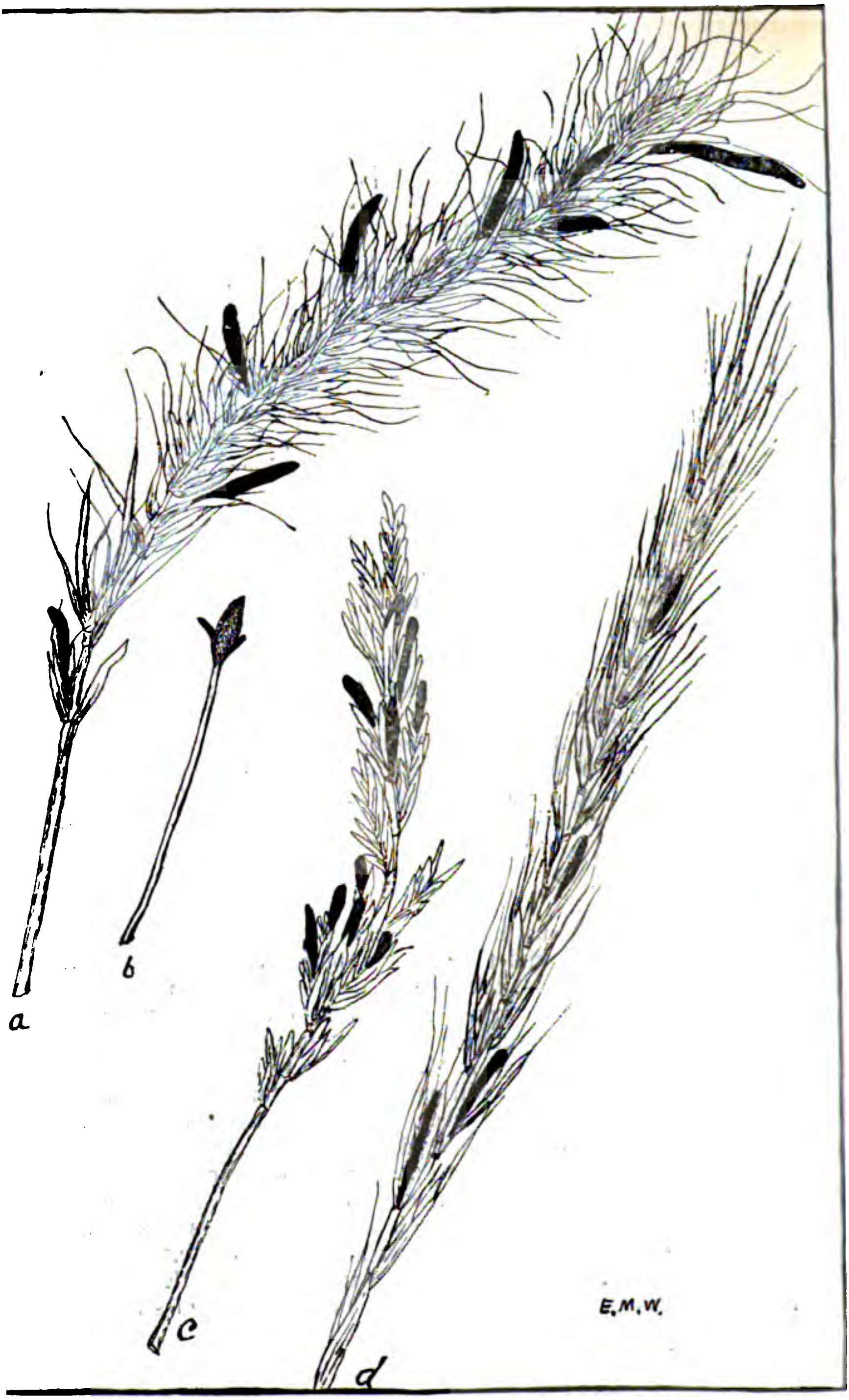
PROGNOSIS: In most cases the prognosis is unfavorable.

TREATMENT: We have no knowledge of a reliable antidote of lupine poison, but it seems that the permanganate of potash treatment is clearly indicated as a chemical one.

The mental excitement may be met with hypodermic injections of morphine or of drenching with a solution of chloral hydrate in water containing some mucilage. The dose of chloral hydrate is 1 to 1½ oz. for horses, and 1½ to 2½ oz. for cattle and ½ to 3 drs. for sheep.

ERGOT.

Ergot is a fungous disease attacking various kinds of grasses. It appears as dark violet or nearly black, cylindrical, slightly curved bodies or grains, taking the place of the grain or seed of the grass. It is these ergot grains that produce the poisoning described below. The interior of the ergot grain is tinged with violet. Ergot grains vary in size, depending upon the grass attacked and upon other conditions. Those found in the heads of the wild wheat grasses are nearly three-fourths of an inch long and one-sixteenth of an inch in diameter. In other grasses they are often much smaller. The grains are sometimes mistaken for the seed of the attacked grass, but a little observation will show the error of this view. In North Dakota, ergot is found most commonly on the rye grasses, wheat grasses, blue joints and reed grasses, but other kinds are also liable to be affected. Ergot grains are fully formed by August and may remain on the grass until late



A VII.—Ergot grains. *a*, on head wild rye; *b*, on head of wheat grass or "blue grass"; *d*, on bearded wheat grass, About natural size.
(Courtesy of S. D. Station.)

in the season. The greater or less abundance of the ergot fungus in different years is dependent in a great measure upon external conditions such as the abundance of moisture; therefore ergot is much more abundant in some years than in others. It is present in all parts of the state to a greater or less degree. As the fungus lives over the winter on the ground and spreads to the various grasses the folowing season by means of spores, it is manifestly impossible to succeed in eradication. Grasses might be grown that were not infected, but it would be poor ecenomy, as our best grasses are the ones affected. As the hay is cut it should be carefully observed to see if it is ergotized to any extent, and if so, it should not be used. A reference to Plate VII wil serve to give a good idea of the appearance of ergot.

The poisonous properties of this fungus have been well known for a considerable period, while its specific action on certain organs have given it a prominent place among the most useful drugs known in medicine. Kobert recognizes in ergot three poisonous substances, namely, cornutine, an alkaloid, sphaceline and ergotic acid. The poisonous character of ergot is principally due to its exciting influence on the muscle fibers of the uterus and on those of the smaller arteries. As a result of the former, contraction of the uterus results, which in pregnant animals frequently results in the expulsion of the fœtus, abortion. The latter action causes the contraction of the walls of the tissue feeding arteries, or a total obliteration of the lumen of the vessel, which prevents the passage of the volume of blood required for the nourishment of the tissues supplied by the vessels mentioned. Tissue, thus deprived of blood, dies, and in such cases we speak of gangrene. Those phenomena may be accomplished or preceded by severe disturbances of the digestive organs. Ergot poisoning is commonly the result of stock eating hay composed of infected grasses or of the feeding of grain (rye) contaminated with the fungus.

Cattle and poultry seem to be more susceptible to ergot poisoning than the other domestic animals.

Symptoms: The severity of the symptoms is largely dependent on the quantity of the poison taken. There is also a variation of the toxicity of different specimens of ergot, the more poisonous ones causing the mose severe symptoms.

Poisoned animals show weakness, dullness and paralytic conditions of certain groups of muscles. When in pregnant animals the uterus is acted upon, labor-pains occur and the fœtus is expelled. The straining in those cases is often very painful and may be so severe that prolapse of the uterus or even the rectum is the result.

In cases of several animals having access to grasses or grain infected with ergot, abortion may occur in several members of the herd, and for that reason infectious abortion may be suspected. It must be remembered, however, that in infectious abortion, the cases are strung out over a greater period and commonly takes place between the fourth and seventh month of pregnancy. In ergot abortion, several animals lose their fœtus in a short space of time and do so at all stages of pregnancy. (For different types of abortion see Bulletin No. 54 of this station.)

When ergot produces gangrene, it usually affects the extremities, like the lower parts of the legs, the ears, tail or teats in cattle, and the comb, wattles, toes, wings or tongue of poultry. It is preceded by redness, coldness and painful swelling of the parts affected. After a while sensibility of the dying region is lost and the line of demarcation between it and the living tissue becomes manifest. The dead portion commonly dies and is cast off. In some cases the gangrene is accompanied by symptoms of a septic nature.

Law and Salmon report an extensive outbreak of ergotism occuring in the United States during 1884, when a prominent symptom presented by the affected animals consisted of ulceration of the mucous membrane of the tongue and mouth cavity. This symptom and the lesions about the extremities give the animals somewhat the appearance of being affected with foot and mouth disease.

The post-mortem appearances, with the exception of gangrenous cases, present no characteristics which will aid us in recognizing the true cause of death.

PROGNOSIS: The possible result of the poisoning depends largely on the amount of ergot taken and on the severity of the symptoms produced thereby. When small amounts are taken and only a slight dullness or digestive disturbance results, the outlook may be quite favorable. Even ergot abortion with rather severe symptoms usually is followed by recovery, but in the gangrenous cases, fatal terminations are common. The animals which through this cause have lost one or more parts are not only crippled but septic or embolic complications may lead to a fatal termination. Paralytic cases do not permit of a favorable prognosis especially if muscle groups containing important functions are involved.

TREATMENT: Frohner recommends tannin as an antidote. The permaganate of potash treatment could be tried in the earlier stages. The physiological antidotes are morphine and chloral hydrate; those especially indicated when symptoms of uterine origin are present. Gangrenous parts or limbs must de dealt with according to the principles of surgery, namely, removal of the dead portions and the application of antiseptics until the resulting wound has healed. A solution of one part of corrosive sublimate in 2500 parts of water is an excellent wash for such wounds.

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GLOSSARY.

Abortion. Premature expulsion of undeveloped young animal.

Antiseptic. A medicine or drug used to restrain the growth of germs or bacteria.

Antispasmodic. A remedy tending to relieve spasms.

Ascending. Said of a plant when its stems are not entirely erect as the stems of red clover.

Asphyxia. A stoppage of respiration due to an abnormal amount of impure blood.

Congestion. A condition of the tissues caused by an excessive amount of blood.

Edema. Swelling of the tissues caused by the presence of a fluid; dropsy.

Embolic. Plugging of a blood vesel due to some obstruction.

Gangrene. Death or loss of vitality in an organ or part of an organ; mortification.

Hypodermic. Pertaining to the area under the skin.

Intoxication. A condition of poisoning.

Lesion. An unhealthy change in function or structure of an organ.

Panicle. The arrangement of flowers on a stalk similar to the oats on the cultivated oats.

Post-mortem. A careful examination of a body after death.

Prognosis. A prediction relating to the future course of a disease.

Raceme. The arrangement of flowers on a stalk similar to that found in the choke cherry.

Regurgitation. A rushing into the mouth from the throat or stomach.

Salivation. An abnormally increased flow and secretion of saliva; especially if caused by drugs.

Sedative. A medicine having the power of soothing or allaying irritation and of depressing vital functions.

Sepsis. Poisonous putrefaction causing noxious effects on organs.

Toxic. Anything of a poisonous nature or showing poisonous effects.

Trismus. Violent spasms of the muscles of mastication.

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Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 59.

TREES AND FRUIT IN NORTH DAKOTA.

By C. B. WALDRON.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

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March, 1904.

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TREES AND FRUIT IN NORTH DAKOTA

BY C. B. WALDRON.

The day of exploitation in North Dakota is rapidly passing and that of home building has taken its place. It is probable that no equal population has a larger proportion of home owners than has North Dakota. This fact coupled with the important one that there is greater wealth per capita in North Dakota than in any other state gives such conditions as should make possible a class of homes characterized by their comfort and attractiveness.

Since the earliest days of man trees have been considered a natural and fitting adornment and shelter for his home. In forests primitive man found his first shelter and protection. Trees were his necessity then and the race can never rid itself of the instincts developed through the long ages of its evolution. We may admire the great expanse of prairie stretching away to the horizon, as we do the boundless ocean, but that does not inmply that it includes the conditions making the most desirable homes. With the home are naturally associated the ideas of individuality, of snugness and, to a certain extent, seclusion, none of which can be attained if the place seems a part of the public domain.

In a region, too, like that of North Dakota, where the winds have fairly earned a reputation for strength and persistence, trees have a use as well as beauty. Passing from the shelter of the forest to open country on a cold windy day one is made aware of all the difference between comfort and misery.

These facts are admitted by everyone, even by those that can offer no excuse for the bare dreariness and desolation that characterize the places where their lives are spent. To spend a lifetime without the presence of a single natural object about which the affections and memories can center, should not be an aluring prospect to civilized man. To busy men with their great amount of necessary work to be done these things are often overlooked, but for all that their importance is not less real.

Attractive homes constitute an active and potent force in shaping and determining the character of society and its members and after all there is nothing important but that.

There are certain elements in people that are accepted as evidences of civilization. These are established for the most part during the period of childhood and youth. Nothing on earth can take the place of a high state of civilization and they make but a poor bargain who sacrifice the possibility of it for wealth or acres.

To rear a generation amid surroundings that because of their dreariness and monotony depress and stultify the mind and imagination instead of quickening and enlivening it, is neither wise nor patriotic. It is not enough to say that we don't intend to do so. It is our duty and privilege to see that we do not. The individual experiences of the most of us bear testimony to the fact that no memories are more vivid or fondly cherished than those of the trees that once offered us protection and company. We feel somehow that their influence was good. Until human nature becomes something different than it is they will continue to exercise a most potent influence on the character of man.

Nations live or die with their forests, as the records of the world testify. Forests are the one great conserving element in nature. The winds and waters are constantly wasting and wearing away the fertile elements of the soil and hurrying them on to the sea, beyond the reach of man forever. By this process, long continued, whole continents have been made desolate and barren beyond reasonable hope of redemption and even within the memory of living man large areas have been rendered useless through the same causes.

Aside from the secondary value of forests in preventing the waste and destruction of cultivated areas, the time has come when the forests themselves have a high money value. It is possible to grow five cords of wood per acre each year for an indefinite period upon millions of acres of our lands. With the present high price of timber, and that constantly increasing, this prospect alone should be an inviting one to the far sighted man.

Trees are grown for three purposes, for shelter, for ornament and for their timber or fuel value. About forty species can be grown in North Dakota. Among these are the white ash, white elm, red elm, rock elm, box elder, solf maple, hard maple, Norway maple, basswood, burr oak, cottonwood, white poplar, walnut, Russian wild olive, hackberry, white willow, birch and mountain ash.

SIZE AND COST OF TREES,

For the planting of groves, shelter belts, etc., seedling trees from one and one-half to two feet high will be found the most satisfactory. They may be procured from any nursery at a cost of from three to five dollars per thousand. Trees that have been transplanted in the nursery cost much more, from ten to twenty dollars per hundred, and are more difficult to transplant.

METHOD OF PLANTING.

In planting seedling trees we ordinarily plow a deep furrow by going down and back in the same place, thus throwing the soil out in both directions. A line is then stretched along the furrow about a foot from the bottom supported by stakes at convenient distances. For further convenience the line may run through holes in the stakes and may be marked at intervals of four feet to give distance in planting.

As the tree are unpacked they should be partially buried in moist earth at different points along the place of planting to keep them in good condition and make them easily accessable to the planters.

Three men are required for planting, one to pass along the line holding the trees in position while a man on either side shovels the earth about the roots. After this process is completed it is very essential to pass along the row and tread the earth very firmly about each tree.

TIME OF PLANTING.

The trees should be set as early in the spring as the soil can be handled. Trees should be ordered early if one wishes to get good quality and to be sure of having his orders filled. They may be ordered shipped on any date. If they arrive before the ground is ready they should be unpacked and spread out in a cool shady place where they may be covered with damp earth cess the green ash may be substituted. Some of the best shelter belts on the station grounds are made up of elm, white ash and soft maple for the inside rows, leaving out the box elder, which is apt to make a poor growth after the first few years, except on very deep moist soil.

For the first few years the windbreak will need to be kept well cultivated. When the trees begin to reach across the spaces between the rows, a heavy mulch of old straw may be applied to the ground to take the place of cultivation. By the time that is gone the trees will have the weed question settled for good. Trees in a wind-break should not be trimmed but allowed to branch freely, clear to the ground if they will. To encourage this the trees are planted further apart than they should be in a grove.

LOCATION OF THE WIND-BREAK.

The location of the wind-break will depend upon the conditions surrounding each place. It is a mistake to plant too close to the buildings. Enclose a space large enough to include the garden and fruit plantation as well as to give a spacious yard about the buildings for planting ornamental things.

Wind-breaks should be so placed that the snow which accumulates on the south side in the winter will not cause inconvenience. If there is some difficulty in doing this a single line of willows planted a few rods to the north of the shelter belt will catch the snow and prevent its drifting through. The space between this row and the wind-break may be used for strawberries and bush fruits which are benefitted by a snow protection in winter. Apple and plum trees so located would be broken down by the snows. Where the shelter belt bounds the lot on which the house stands either at the sides or rear or both, it may be greatly improved in appearance by planting more or less irregular masses of shrubbery against it. These break up the rather formal and harsh appearance of the straight lines of trees into something more artistic and effective. As the trees get large a place without shrubbery looks desolate and cheerless compared with the comforting and homelike appearance that shrubs give.

The shrubs suited for this purpose will be given in another part of the bulletin.

TREE PLANTING FOR GROVES.

The primary purpose in planting a grove is to establish a wood lot on which to draw for supplies of fuel and posts as they

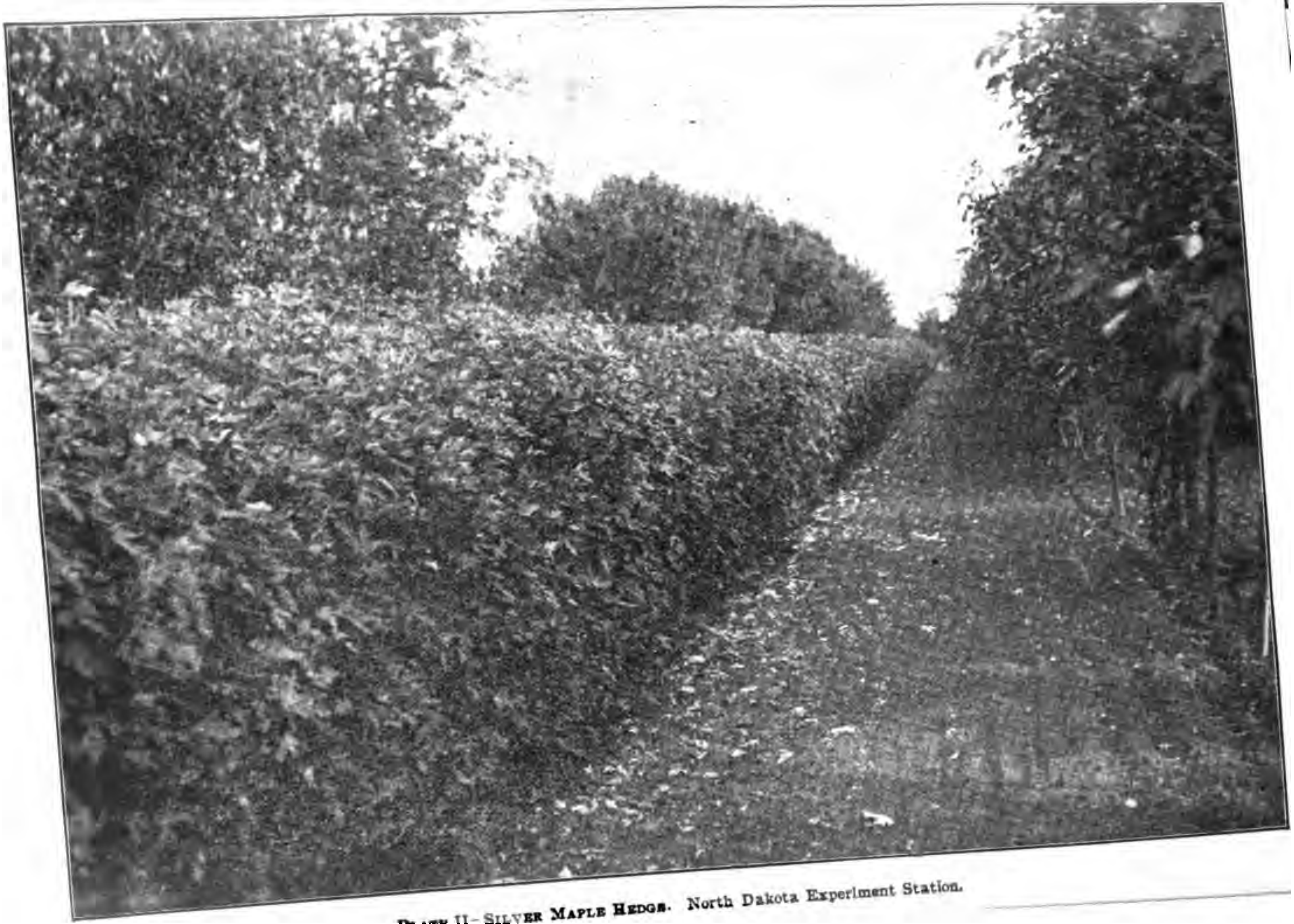

PLATE II—SILVER MAPLE HEDGE. North Dakota Experiment Station.

are needed on the farm. Incidentally it may be made a very attractive feature of the farm and also serve for shelter.

The increasing scarcity of timber for all purposes is making the timber question a very important one. Timber is being removed from the forest areas of the country to day about twice as fast as the forests can renew it. This of course will lead to a condition when growing timber will become a necessity.

Already timber-growing on a commercial scale has been entered upon in some parts of the country. It is doubtful if timber-growing will ever be established as a great commercial enterprise in North Dakota. At the same time the value of a wood lot on each farm if properly grown, will in most cases more than compensate for the time and money required to grow it.

The work at this station has not been extended enough to answer in a practical way all the questions that might be asked concerning timber culture. We can only call attention to the experiments we are making and to what we have seen in other groves including the belts of native timber.

Among the trees that will succeed well in groves are the willow, white ash, green ash, American elm, rock elm, solf maple, box elder, basswood, birch and white poplar. They are all native trees but will not of course all succeed equally well in all parts of the state. The green ash is found wherever trees will grow at all and the elm is also widely distributed. The soft maple and the basswood seem to require moist soils, such as are found along river bottoms..

It will be noticed that the cottonwood and balm of Gilead both native trees and rapid growers have been left out of the list of trees suited for groves. The balm of Gilead may possibly be used to some extent but the cottonwood is not to be considered. Planted singly it does well and is a useful tree but it demands too much light and gives too little shade to make it a possible forest tree. It is also a well known fact among tree growers that other trees will not thrive in the vicinity of cottonwoods.

DISTANCE APART FOR PLANTING,

Trees suited for groves ordinarily do not make a good growth when planted some distance apart unless they are of considerable size when planted. A seedling elm or ash left to itself tends to grow in the form of a bush and makes little progress in height. For this reason seedling trees of the varieties named must be planted close enough together to shade each other at the sides.

PLATE III—SHELTER BELT OF WHITE SPRUCE. North Dakota Experiment Station.

This will prevent the growth of lateral branches and compel an upright growth.

Trees in a grove to be of any value should be tall and straight. By being forced to stretch up to get the light they naturally become so.

Two feet between the trees in a row is about the right distance at first. The rows may be far enough apart to cultivate easily with a two-horse team or about eight feet. The soil should be in such a shape that it may readily be cultivated. The method of planting has already been described.

Trees like the box elder, making a quick growth but being short lived are used simply as nurse trees to get the others started. They shade the ground quickly and in that way are a benefit to the other trees. The permanent trees are those like the elm, ash and basswood. Every other tree should be a nurse tree. Between these the permanent trees may be distributed as suits the fancy of the planter. The larger growing trees like the elm and white ash should not be nearer than eight feet apart in the row. The green ash makes a quicker growth than the white ash but does not continue it so long. It may be used as a semi-permanent tree planted half way between the larger kinds. Its timber is valuable for posts or fuel.

CULTIVATION.

While small the trees may be cultivated the same as corn with an ordinary two horse cultivator. Another excellent tool for this purpose is the acme harrow. This cuts about seven feet wide. It is a good weed destroyer and leaves the soil well pulverized and in good shape to retain the moisture. With it one can cultivate an acre of trees an hour.

Until the trees begin to shade the ground they should be cultivated frequently, about once in ten days or two weeks and especially after every rain. In ordinary seasons the cultivation should continue until late in the fall but in seasons of excessive rainfall the cultivation may stop late in the summer to give the wood a chance to ripen for winter.

In dry seasons cultivation is more imperative than in wet. As the trees become large enough to shade the ground, which they will do very quickly if well tended, less cultivation will be required and after four or five years they will need but little. In most cases it can be done away with entirely and a good mulch of old straw will meet all requirements.

PRUNING.

During the first and second years the trees will be benefitted by cutting off the side branches to keep them from forking and to force an upward growth. After that they should shade each other enough so that side branches will not form. This work may be done in the spring or summer, not later than July, or in the late fall. Pruning late in the summer forces a late growth that will not mature before winter.

THINNING.

Left to themselves, no matter how thickly planted, the stronger trees gradually out-top the weaker ones and thus nature does her own thinning. One can save time however and get better results if this process is not left wholly to nature. When the trees show evidences of being crowded a part of them should be removed. These will naturally be the nurse trees that have served their purpose in getting the others started. If desired for planting elsewhere they may be dug out late in the fall and heeled in for winter in some spot where the snow will drift over them or they may be dug out in the spring and planted at once when needed.

These trees being nursery grown should be tall and straight and well suited for street or lawn planting. They have a market value of about ten dollars per hundred, an acre producing 1360 trees where none are missing. This still leaves the trees standing four by eight feet apart and in time these will need further thinning.

LIST OF TREES FOR TIMBER PLANTATION.

White Ash .The wood of this tree is strong and durable. It is used where strength and elacticity are required as in fork handles, whiffle-trees, the manufacture of vehicles, farm machinery, etc. It is fairly durable when used as posts and has a high fuel value. The wood of the green ash has much the same qualities. Both of these trees are slow to leave out in the spring and shed their foliage early in the fall. For that reason they should be planted with other sorts not having this defect in order to better prevent the growth of grass and weeds among the trees.

American Elm. This is of little money value to the farmer except for fuel. The wood is not durable in contact with the soil. Its value is chiefly as a shade tree.

Basswood. The timber of this tree has no special value except for fuel until such time as the trees are large enough to be made into lumber. It is then in demand where a light, stiff material is required as in the manufacture of trunks, etc.

Silver Maple. This is also known as white maple and soft maple. Its only timber use for the farmer is for fuel. It should not be planted singly as it is easily broken by the winds. It is very ornamental and holds its foliage well. Its chief use is as a shelter and nurse tree.

White Willow. This tree grows rapidly and makes a large amount of fuel in a few years. When well seasoned it makes a post that is fairly durable. Its hardiness and the ease with which it is started makes it one of the most valuable of trees for prairie planting.

Golden Russian Willow. Has much the same habit as the white willow but grows faster, at least when young. Is more especially suited for hedges and shelter belts.

Box Elder. A quick growing, short lived tree. The timber has no value except for fuel. Its chief value is as a nurse tree and for lawn and street planting7. Unless the top is kept thinned out it becomes scraggy and makes a poor growth. With heavy pruning from the time it is a young tree it grows into a symmetrical tree that makes a dense shade.

Burr Oak. This is the only native oak. Its timber is valuable for many purposes, but its growth is too slow to make it a profitable tree for planting.

White Poplar. A native tree growing in dense groves along the streams and in the northern part of the state. Grows rapidly for the first fifteen years. Will produce as high as ninety cords of wood per acre with eighteen years growth. As it springs up thickly from suckers it reproduces itself without planting. On this account it is probably one of the best fuel trees that can be grown.

Hackberry. A native tree having something of the character of the elm to which it is botanically related . While not attaining the size of the elm it is in some respects a better tree growing more symmetrically and thus requiring less attention. It is rather better adapted for lawn and street planting than for timber plantation though it succeeds well there.

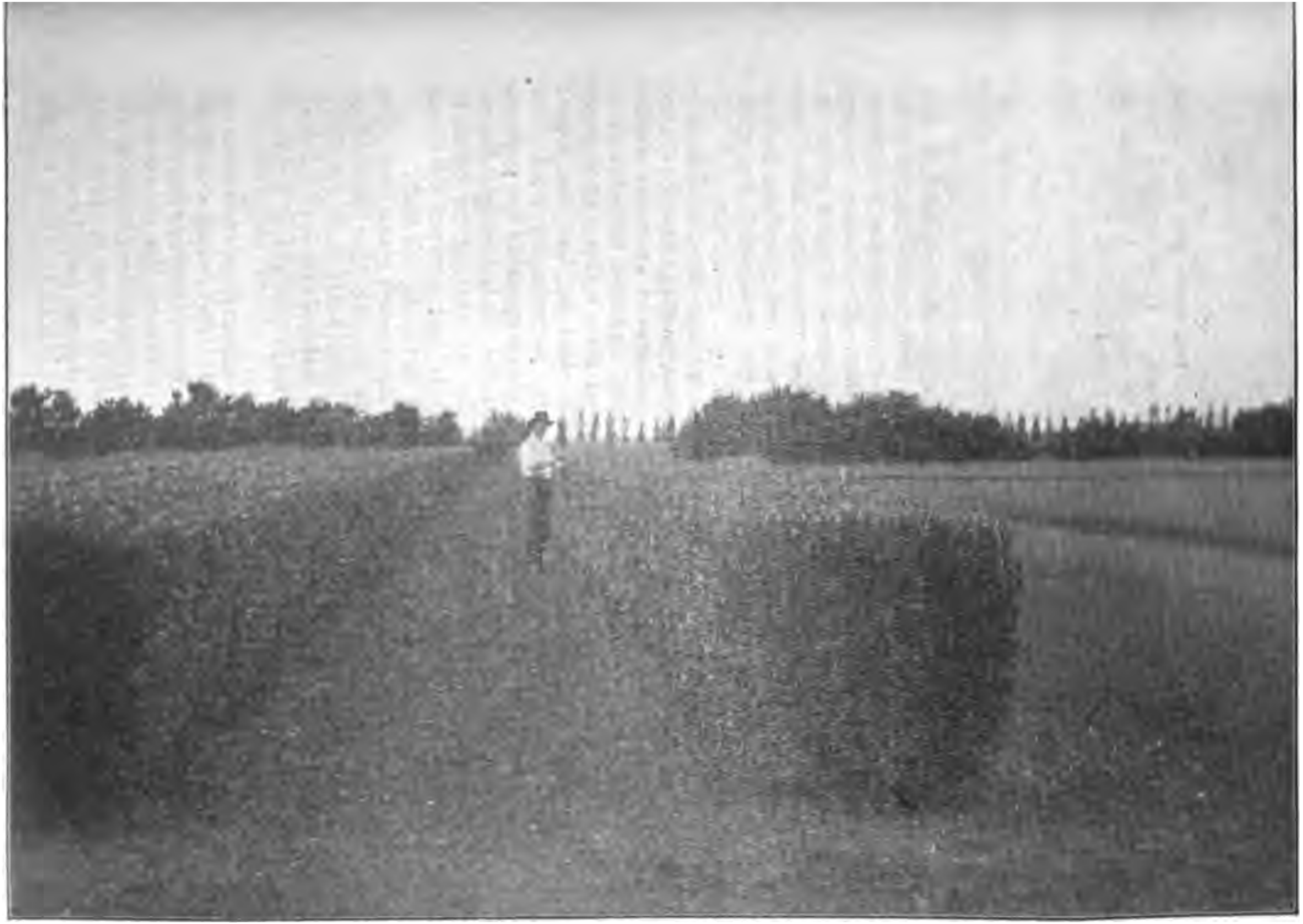

PLATE IV—HEDGES OF RUSSIAN WILLOW. North Dakota Experiment Station.

American White Birch. When of sufficient size the birch is made into lumber for the manufacture of furniture and various wooden implements. The chief use of small trees such as are found native in the northern part of the state, is for fuel. This tree makes a fairly rapid growth and its extreme hardiness and striking beauty lead to its being largely planted.

STREET AND LAWN PLANTING.

The interest in tree planting to improve the appearance and comfort of our towns and villages is being made manifest in many localities. At other points little or nothing has been done and as a result their cheerless and forlorn aspect makes a sorry comparison with the beauty and attractiveness of their more enterprising neighbors. All of the timber trees that have been named are more or less suited to street and lawn planting and in addition there are other smaller sorts that are useful for ornamental purposes only.

Throughout the middle and northern states the elm is usually looked upon as the best tree for street planting though at the present time the box elder and the cottonwood are more extensively used in North Dakota. The elm combined with these, or rather with the Carolina poplar and box elder makes a good combination. On the outside of the walk, plant the Carolina poplar and elm alternately, leaving twenty feet between the trees. On the inside of the walk plant the box elders opposite the poplars. At the end of fifteen or twenty years the poplars should be removed leaving the elm and box elder alternating on opposite sides of the walk with a space of forty feet between the trees of each row and a tree for every twenty feet along the walk.

It is the ordinary practice to set trees much closer than this and never remove them. Some people are too kind hearted to cut down a tree. Others have still kinder hearts and cut down some that the remainder may grow into natural and perfect shape. Such trees live longer and unless one takes pleasure in deformed things look better.

Trees for street planting should be nursery grown if possible and in all cases should be headed high. The trunks should be straight and two inches or more in diameter excepting the Carolina poplars which may be smaller. It is difficult for a very small tree of most varities to grow tall and symmetrical when set in an open and exposed place. They should be grown in the nursery long enough to give them an established form and character.

PRUNING STREET TREES.

The butchery that it has seemed fitting to perform on street trees to keep them within bounds just at a time when they should be growing into their greatest beauty could be obviated by giving them the proper attention when young.

Branches of old trees are pretty sure to droop and get in the way unless is headed well up from the ground and kept that way by cutting away the lower branches while they are small, long before the trees seem to need it. This process increases the rate of growth of the upper and outer branches and gives what is needed, a tall spreading tree.

The elm has a tendency to an irregular or even sprawling habit of growth. This should be corrected by cutting back the extending branches making the top symmetrical. The box elder should be kept well trimmed from the bottom from the time it is planted and its growth will be faster if the interior limbs are removed before they become too thick. Trees with open tops like the cottonwood may be improved by keeping the tops cut back thus making them more dense. The hackberry requires little or no pruning except to keep the lower branches cut as it develops in height. The typical street tree is one headed high enough not to interfere with traffic and to allow an open view between the house and street, under the trees. The general effect is also infinitely better if the pruning be done gradually as the tree grows instead of waiting till one final day and then cutting off most of the branches, leaving crippled, crooked trunks surmounted by a pinched and straggling top.

ORNAMENTAL TREES AND SHRUBS.

The average lawn requires but few large trees and these will ordinarily be at the sides and rear. Small compact trees and shrubs give a better effect and these should be arranged so as not to break up the open effect in front nor interfere with good views from the house.

Planting in irregular masses about the boundaries of the place and close against the house leaving a free open expanse of lawn between will give the best results.

We have over thirty shrubs growing upon the station grounds and there are very many more suited to this latitude. There are several trees like the cut leaved weeping birch, mountain ash, blue spruce and black hills spruce that are especially adapted for lawn planting.

The Cut Leaved Weeping Birch easily stands at the head of all trees for planting upon the lawn. It grows rather rapidly while young but never attains very great size. It should be planted where other trees will not crowd it and where the branches may be allowed to droop to the ground. On account of its rich and elegant appearance it must be planted very sparingly, not more than two or three trees upon small grounds.

The Mountain Ash is another tree of great beauty. Its rich dark foliage and bright red berries give it a very striking appearance. It is perfectly hardy but somewhat liable to sunscald making protection of the trunk necessary in very exposed places. Like the birch is should be planted sparingly.

The Colorado Blue Spruce is the most striking of all evergreens on account of its silvery blue color. It is hardy in northern latitudes, but should have some protection against south winds as indeed all evergreens should. It grows into symmetrical form and because of its acknowledged beauty should be generally planted.

The Red Cedar is one of the hardiest of the evergreens, growing wild in the western portion of the state. It starts rather slowly, but soon grows about a foot a year becoming a compact and very ornamental tree.

The Black Hills Spruce is a form of the White Spruce but often closely resembles the blue spruce in color. It is very hardy and desirable.

Of ornamental shrubs the Common and Persian Liliac, Snowball, Tartartarian Honeysuckle, Barberry, Red Dogwood, Burning Bush, Ninebark, Spirea (Van Houtii,) Juneberry, Choke Cherry, Buckthorn, Whitethorn, Buffalo Berry, Golden Currant, Elderberry (black,) Red Berried Elder, Sumac and the Rugosa Roses are all easily grown and very ornamental.

They should be grown for the most part in clumps or masses close about the porch and sides of the house to relieve the bareness of the building and also where walks diverge or curve, or against the larger trees to hide the trunks. Shrubs give a rich and soft aspect that cannot be attained by other forms of planting.

PLATE V—YOUNG PLUM AND APPLE TREES. North Dakota Experiment Station.

HEDGES.

The plants now growing at the station for hedge purposes are the buffalo berry, wild plum, silver leaf *(Eleagnus argentea),* Caragana, Buckthorn, Russian Wild Olive, Tartartian, Honeysuckle, silver maple, golden Russian willow and red cedar.

They may be divided into two classes, those used for fences against stock and the strictly ornamental hedges though of course all may be made more or less ornamental.

The golden Russian willow is the one we have planted most extensively probably because it costs less to get it started. It grows readily from cuttings, is very ornamental both in summer and winter and when required grows large enough to make a fine shelter and heavy enough to protect against stock.

The cuttings are set early in the spring about a foot apart and in soil that can be kept cultivated. The cultivation should continue along the sides of the hedge for three or four years. After the plants are two or three years old they should be cut back to the ground so they will make a dense growth. The other plants making heavy stout hedges are the buffalo berry, wild plum, Russian wild olive and silver maple. These are not grown from cuttings, but from young plants. In some respects the buffalo berry makes one of the best hedges. It is of course perfectly hardy, is free from disease or insect attack, well armed with formidable spines, holds its foliage till very late in the season, and is very ornamental. The fruit is also valuable in making jelly.

When grown in cultivated ground it has the habit of sending up suckers about the old plants. While these may be easily kept down yet the habit may be considered a slight objection to the plant. When the land alongside is seeded down the suckers do not appear.

The wild plum suckers worse than the buffalo berry, but as with that plant, when the land has once been seeded down, the tendency to sucker is not serious.

Both of these plants require less attention in the way of trimming thn the willow, but on the other hand do not grow as fast. They should also be planted about a foot apart and kept cultivated till they are well established. The silver maple is a stronger grower than any of the plants mentioned and makes an excellent hedge. Ie requires however a deep moist soil and is not generally considered a success outside the Red River Valley. Where a hedge is required large enough to afford a shelter it is probably the best plant to be found in soils where it will grow.

In starting a maple hedge seedlings of course will be used. They may be set one and a half or even two feet apart. If allowed to do so they will naturally grow in the form of a bush which makes them the more valuable for hedge purposes. The silver maple is not so easy to start as the willow but is rather more thrifty after the first few years as the interior branches stand shade better than those of the willow.

The Russian wild olive has been tried but two years with us and in a small way at that. It is very highly spoken of as a hardy, drouth resisting plant. The tree growers in western Nebraska have placed it at the head of their list. It resembles the buffalo berry in the color of its foliage but is a more rapid grower and more showy. The plants on the station grounds grew two feet last season. It has not winter killed with us, though Mr. Uelland Uelland at Edgeley reports the tops having killed back a little with him. It holds its foliage till winter, does not sucker, grows into good form for hedges and is well armed with stout spines. We shall plant it largely next spring. If it proves hardy it ought to make a valuable hedge about school grounds and similarily exposed places.

ORNAMENTAL HEDGES.

All of the other hedge plants named are valuable for ornamental purposes only, though some of them have often sold by tree peddlers under the name of "Siberian hedge," etc., with the assurance that they will turn stock in three years. It is impossible to tell which is the best of these as no one is the best for all purposes. The buckthorn makes an excellent hedge and in time will afford some protection against dogs and stock. It has rich, dark green foliage that remains on till late in the fall. It requires little attention, does not sucker and makes a dense growth. It is slow about getting started but does well when once established.

The Caragana starts readily and will make a fairly good hedge in three years. The foliage is light green and while very beautiful in early summer is apt to rust and get dingy later in the season. It is very hardy and a valuable plant.

The silver leaf is a native of the state and is sometimes known as the badger bush. It grows readily into a low, pretty hedge but suckers badly.

The Tartartian honeysuckle is about the best plant, all things considered, for an ornamental hedge. It is perfectly hardy, a profuse bloomer, starts readily, is not subject to disease or insect attacks, and will succeed with any reasonable treatment.

It will grow eight or ten feet high as a dense, stout bush, or may be kept trimmed to any height. The red cedar is probably our surest evergreen and is well adapted for hedges. Trees obtained from Minnesota seem perfectly hardy. It is not a rapid grower, though last season our trees made a growth of about a foot. It is of course an ornament the year round and for that reason should appeal to those wanting something unusually fine if they are prepared to give it the attention it demands till it becomes established. The plants of the red cedar should be set about two feet apart, of the others named, about one foot.

TRIMMING HEDGES.

For this purpose a straight corn knife kept well sharpened is used. The straggling branches are lopped off by quick upward strokes. The trimming may be done any time in the summer, not later than the last of July, or the last thing before winter sets in. Trimming in late summer causes a new growth to start that is likely to be winter killed. The older branches in a hedge as they begin to get scraggy may be cut out entirely and sometimes it is necessary to cut the whole hedge back to the ground to get a new healthy growth.

No one feature on our own grounds is more admired than the hedges and considering the ease with which they are grown and the necessity for some sort of boundary about the place for shelter and protection there is no reason why they should not be universally planted.

FRUIT CULTURE.

The success that the Experiment Station and many private growers have had with small fruits has led to numerous inquiries as to the methods employed and the varieties that may be recommended. We do not advise anyone to attempt the cultivation of fruits without providing for their shelter by means of windbreaks. This is particularly true of strawberries that suffer greatly through the effects of drying south winds and applies in a greater or less degree to all fruits.

The shelter should be along the south as the destructive winds come from that quarter. For the location of the fruit plantation

Plate IV—De Sota Plum Tree in Fruit. North Dakota Experiment Station.

select a north or northeast slope where it can be obtained and at any rate avoid a south or west one.

Provision must also be made such that water will not remain on the ground for any length of time during the spring thaws or after heavy rains.

Where the rainfall is not heavy, as in North Dakota, one should avoid a sandy or gravelly soil. In mellow soil the roots of strawberries extend down two and one-half feet and of the other fruits probably as deep. From this fact will be seen the necessity of providing a place having a deep mellow soil free from gumbo and of course from alkali.

Any soils excepting those naturally too light will be benefitted by a deep plowing and subsequent firming down with a harrow. We have not found it necessary nor even profitable to fertilize the soil at the station on which fruit is growing. Of course soil having a much less degree of fertility would be benefitted by plowing under a good dressing of well rotted stable manure. Unless it is so thoroughly decomposed as to mix readily with the soil it will be better not to use any. It is generally recommended that currants and gooseberries have heavier soil than raspberries and while that rule may be successfully applied in localities having variable soil and a heavy rainfall it is sufficient to say under our own conditions that the deepest and best soil should be selected on which to grow all of our fruits. While there are undoubted difficulties to be encountered in growing fruit in North Dakota, still some of the fruits may be made to do unusually well here and considering the high prices to be obtained others are quite as profitable here as in more favored localities.

PLUMS.

The plum is the most valuable fruit for North Dakota and doubtless will be for years to come. Wild plums of many types, some of them of excellent quality are found growing in all parts of the state. The demand for these now far exceeds the supply and the general cultivation of the plum should begin at once.

Many of the thickets contain trees bearing fruit of good quality and these may be transplanted to the home garden with profit. A hundred trees thus selected twelve years ago have been growing upon the station grounds since and have been the source of hundreds of seedlings that are now coming into bearing. In this way improved varieties may be obtained that are of course well suited to the different localities in which they are grown.

In this way also one may be sure of securing a variety sufficiently early to ripen before frost as all of the sorts of the American Plum brought from other localities will not. There are now over a hundred varieties of the same plum that is found growing wild in our state offered for sale.

A few of these are growing at the station, the most of them just coming into bearing. These were only partially protected on the south and last fall a violent gale coming just after an excessive fall of rain blew them over. They were then removed to a better protected location. This circumstance shows that it is quite necessary to provide good shelter, though it must not be placed so as to allow the snow to drift over the trees.

The trees may be further protected by planting them close together, as close as six by ten feet. They should be planted considerably deeper then they grew in the nursery row or native thicket. This will enable them to stand the winds better and will afford better root protection in winter.

Before planting the land may be ridged by plowing it in narrow strips setting the rows of trees between the ridges in the dead-furrows, pulverizing the soil well first. With this method of planting, which insures loss from drouth, a quantity of black surface soil should be put around the roots of each tree in planting.

Keep the grass and weeds out and the soil moist by frequent cultivation. The trees will begin bearing in three or four years. A mulch of old straw spread on the ground after cultivation for the season has stopped will prevent root-killing in any open winters. It may also be necessary to bind tar paper about the trunk of each tree in the winter to protect from mice and rabbits. There is a very large list of varities to select from that are a decided improvement over the ordinary wild type, especially in size. Some of these ripen their fruit too late for the far north. The De Soto, Forest Garden, Cheney, Wolf, Rollingstone, Wyant and Surprise is the list recommended by the Minnesota Horticultural Society for general cultivation.

APPLES.

To the average man fruit growing means apples. All over the country on farms where no special effort is made to raise fruit one will find apple trees growing. Because of the great adaptability of the apple to meet varying conditions this is true over large regions that a generation or two ago produced no apples. Generally speaking it has been found that the apple is introduced into regions of new conditions only as new varieties have been created to suit those conditions. Practically all of the apples grown in the eastern states today are of varieties that were created there and the same condition is being found true in the Northwest. Aside from the Russian apples that were created under conditions similar to our own the only possible apples with us are those like the Lyman's Prolific, Wealthy, Patten's Greening, etc., apples that originated in the northwest.

While the development of new varieties is a thing apart from apple culture as generally understood, yet in a new country where apple growing is more or less uncertain because of the absence of thoroughly hardy varieties all who are interested in the development of the apple industry will be planting apple seeds from time to time. In ten years most of the trees thus produced will be bearing fruit. There were exhibited at Minneapolis last fall over one hundred seedling apples, many of them of high quality, all grown from apple seeds planted ten years ago.

At the same time, it is possible to accomplish something with the varieties in existence. Crabs and bybrids of the folowing varieties have been found suitable for growing in the Northwest: Virginia, Whitney, Early Strawberry, Minnesota, Gideon No. 6, Florence and Lyman's Prolific.

Among apples suited for the same region are the Duchess, Hibernal, Charlamoff, Patten's Greening, Wealthy and Malinda.

Apples in this region seem to succeed better if the trees are headed very low, those heading right at the ground after the original tree had killed back often proving the most profitable trees. Where the soil will admit it it is advisable to plant the trees from six inches to a foot deeper than they grew in the nursery. Trees thus planted naturally grow a little slower and ripen their wood better thus possibly reducing the danger of blight and winter killing and at the same time they are less affected drouth.

Ordinary varieties may be planted about twelve by sixteen feet apart or if they have good shelter and rich soil, sixteen by twenty feet. It is not wise to try and grow apples without a good shelter belt on the south and west. This may be planted at the time the trees are set. It is a poor plan to buy large trees. They cost more and are worth less for the planter. It is better to buy two year old trees or even root grafts. When one does not feel like investing much money in apple trees he can buy root grafts of the best varieties for three or four cents each that will make him as good trees in eight or ten years as he would obtain

Plate VII—Picking Strawberries. North Dakota Experiment Station.

through planting trees of the regular size. Root-grafts should be planted deeply, leaving a single bud above the ground. The situation may be still further improved by planting them in a broad trench made with a plow.

Clean cultivation for apple orchards is undoubtedly the best, especially in a dry country. In very wet seasons a bushel of oats to the acre may be sowed upon the land late in July and harrowed in. These will help the trees to ripen their wood and will afford a protection in winter. They will not greatly interfere with cultivation the following spring. The apple blight must be guarded against and when twigs or branches turn brown and die, usually in June, they must be cut off and burned.

It is found best not to trim apple trees much in regions like our own, but rather to let the head grow dense and compact to protect the trunk and larger limbs. The line of sucessful apple culture has moved toward the northwest so rapidly during the past twenty-five years that North Dakota also has something more than a reasonable hope for future success.

CURRANTS AND GOOSEBERRIES.

These are already successfully grown more or less in most sections of the state, yet there are thousands of homes where the cultivation of even these valuable and easily grown fruits is not attempted. They thrive best in deep moist soil. Given that and clean cultivation, at the same time allowing about eight canes to grow to the hill, cutting out the canes four years old and allowing only enough new ones to grow each vear to take their place, and any one can grow these fruits in abundance.

Set the plants four by eight feet apart and see that the grass does not get a foothold among the plants. They will stand a richer soil than most fruits and stable manure forked into the soil close to the plants will increase the yield. If too many canes are allowed to grow in a hill, the fruit is small though the seeds are all sure to be there.

The London Market is the best currant we have tried. The North Star, Red Dutch, Victoria, White Grape, Long Bunch, Holland, Pomona and Red Cross are all standard sorts. The Downing Champion and Houghton are the leading gooseberries.

RASPBERRIES.

Our sucess with raspberries has not been encouraging though some have met with considerable success. With a better drained soil we think we could do better but unless one is prepared to put considerable work upon his raspberry plantation such as covering the plants in winter, keeping the suckers cut out as fast as they appear, etc., he had better confine himself to the other fruits.

This is not saying that with a good location and some time at his disposal a man might not be well repaid in his efforts to grow raspberries. There is no particular secret in their cultivation, at least if there is we haven't found it here. Set the plants four by eight feet apart, far enough to make cultivation easy. Allow six new canes to grow in each hill each season, cutting out all the rest. Remove the old canes in the fall, those that have borne fruit, so the new ones may be protected easier.

For protection bend them all to the north throwing dirt on the tops to hold them down. After that plow a furrow on either side of each row throwing the soil over the plants. If covered with straw they are liable to injury from mice. Lift the canes in the spring as soon as the weather is settled.

About the only varieties that have made much of a showing with us are the Cardinal, Colorado, Iron Clad and Loudon.

STRAWBERRIES.

Since our windbreaks have become established we have not experienced much difficulty in producing a good crop of strawberries each year. Last season there was no rain to speak of till after the fruit was ripe and yet the yield was very good.

The strawberry requires a well drained but moist soil. Avoid land that is very weedy, especially that containing fox tail and quack grass. Set the plants in early spring, plainting them firmly with the roots spread out and extending straight down and the crown just at the surface of the ground. Give them plenty of room to make cultivation easy and to allow each plant a good share of moisture. We set our plants two by four feet apart. If the soil is rather dry or weedy keep all of the runners cut off for the first season and make the cultivation very thorough.

If the soil condtions are good about three runners may be allowed for each plant training them along the row so they will not interfere with cultivation. In the fall after the ground begins freezing cover with three inches of straw that is free from seeds of any kind. Take it from the side of the straw pile opposite from where the machine stood. In the spring when the straw is dry on top but still somewhat moist at the bottom, it may be burned off. If done at the right time enough will remain to spread about the plants as a mulch to retain the moisture and to keep the berries clean. After the first crop has been harvested the bed must be put in shape for the following year's crop. This is done by thorough cultivation for the remainder of the season, and the removal of runners as they appear.

It must be remembered that the fruit for any given season is all provided for and made ready the previous season. Unless the plants are kept thrifty and vigorous they will not find it possible to prepare for much of a fruit crop. In July and August the soil will become hard and baked unless constantly stirred. It is just at this time however that the plants should be doing their best work for the future and must not be neglected. If the bed is well tilled after the first crop removing most of the old plants and encouraging the young ones, the second crop will be as large as the first one. By continuing this same method we have grown three good crops in succession on the same land and last season one old bed was put into shape to see what the fourth crop will amount to. It is generally advised however to grow but two crops and then plow up the bed.

VARIETIES.

Out of the thirty-four varieties in the trial bed last season the following gave the highest yields, coming in the order named: Warfield, Tennessee Prolific, Emperor, Senator Dunlap, Sample, Wm. Belt, Beder Wood, Drouth King and New York. Of these the Warfield and Sample are not self-fertilizing and will need to be planted in alternate rows with some of the other varieties.

Considering vigor, hardiness and quality, the Senator Dunlap made perhaps the best showing. Twenty-four plants set in 1902 gave twenty-four and one-half quarts in 1903.

The Wm. Belt is another excellent berry and very large. We raised single specimens measuring seven inches in circumference, twelve of them filling a quart box. In all the tests made the plants were not watered. While the price for strawberries in North Dakota is very high, still we would not advise growing on a large scale till one is able to grow them successfully in a small way. To be successful one year with another it will be necessary to have a well sheltered location. With a good location and a thorough knowledge of the business a profit of from two to five hundred dollars per acre should be obtained. The late varieties will ordinarily pay the best as everything is out of the market by the time they are ready and fifteen to eighteen cents wholesale can easily be obtained. Whether the proposition from a financial side is an enticing one or not, there are few people so situated that they may not have an abundance of this excellent fruit for house use.

C. B. Waldron.

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NORTH DAKOTA AGRICULTURAL COLLEGE

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Experiment Station

F

NORTH DAKOTA.

Bulletin No. 60.

ANALYSIS OF FORMALDEHYDE SOLD IN NORTH DAKOTA.

By E. F. LADD.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
April, 1904.

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ANALYSIS OF FORMALDEHYDE SOLD IN NORTH DAKOTA.

BY E. F. LADD.

Last year there were frequent complaints that much of the formaldehyde sold in the state was of inferior strength. As proof of this statement several samples were sent by interested parties for analysis some of which were found to be of good strength while many others were found to be, as claimed, weak solutions. From our analysis for 1903 I select a few where the results indicated the solutions to be weak in strength.

Samples from	Per Cent.
Knox	26.27
Moorhead	27.72
Casselton	28.90
Casselton	31.98

Our analysis for 1903 shows clearly that the formaldehyde sold was not always as claimed, a 40 per cent solution.

There were also further complaints that the amount sold by druggists, for a pound or a pint, was not always full measure and some of the bad results were to be attributed to this cause. The manufacturers and jobbers were inclined to blame the druggists for this weak condition and for the short weights.

The matter was taken up during the summer of 1903 with the manufacturers and jobbers and we were assured that in 1904 the formaldehyde should be of full strength.

The loss to the farmers of this state in 1903 amounted to thousands of dollars, caused by using weak formaldehyde and short measure. In many instances farmers who treated their seed wheat to destroy smut reported no improvement in the crop when harvested over that of the untreated wheat. Here then, the farmers lost the cost of the material, cost of labor in treating his seed, suffered a loss of 10 to 20 per cent in yield and were obliged to sell for a lower grade than where the treatment had been successful. Naturally, the farmers felt that there was something wrong, either the formaldehyde was not of proper strength or that the method recommended, for treating the wheat, is in practice, a failure. For information and aid they have naturally turned to the Experiment Station for assistance in a matter of such vital importance.

It was decided early in the season that we would undertake an investigation to determine where the real trouble lay and druggists were invited to send samples of formaldehyde for analysis. As far as possible we have tried to secure from the druggist the name of the wholesaler and manufacturer so that we could trace each sample to its origin.

The commercial formaldehyde is supposed to be a 40 per cent solution and on this basis the method was worked out by Professor Bolley for treating grain for destroying smut. No genuine sample, to be of good strength, should be less than 38 per cent and when the analysis shows less than 37 per cent it cannot be recommended as suitable for use on the basis recommended for destroying smut. Experiments have demonstrated that too strong a solution will kill the wheat while a too weak solution does not kill the smut. The range, however, is sufficiently wide so that there is no danger where the formaldehyde is of normal strength of injuring the wheat or of failure to destroy the smut.

In the following I have given the name of each manufacturer or jobber and in the table the source of the sample and the per cent of formaldehyde found.

The following samples from druggists were reported as having been purchased from Lyman Eliel Drug Co., Minneapolis.

Where from. Retainer.	Per Cent.
Fargo, carboy	37.80
Fargo, carboy	37.35
Fargo, carboy	38.81
Oakes, unknown	36.90
Walcott, unknown	38.25
Average	37.86

The above gives an average of 37.88 per cent and a range from 36.90 to 38.81 per cent. The average is rather below the desired standard but nevertheless the product may be classes as being of good quality.

The following samples were reported by druggists as having been purchased from Noyes Brothers & Cutler, St. Paul, Minnesota.

Where from. Retainer.	Per Cent.
Willow City, unknown	39.83
St. Paul, bottled	42.41

Willow City, unknown	39.04
Osnabrook, carboy	38.70
Brazil, unknown	38.93
Havana, unknown	37.91
Willow City, unknown	40.08
Finley, unknown	39.88
Alice, unknown	39.71
Willow City, unknown	40.02
Minot, carboy	39.15
Bisbee, carboy	40.84
Average	39.71

The above shows an average of 39.71 per cent and a range from 37.91 to 42.41 per cent. The product proves to be of very uniform strength and not far below the required standard.

Druggists report that the goods from which these samples were taken were purchased from the Leithhead Drug Co., Duluth, Minn.

Where from. Retainer.	Per Cent.
Courtenay, carboy	25.42
Walcott, carboy	33.86
Fessenden, unknown	31.38
Taylor, bottle	33.19
Casselton, unknown	38.13
Cooperstown, unknown	33.75
Cooperstown, unknown	33.86
Grand Forks, unknown	39.15
Average	33.53

(In justice to the Leithhead Drug Co., it should be stated that they report having purchased their goods from the Dr. Leininger Chemical Co., of Chicago, with a guarantee that it was to be 40 per cent in strength. They further submit their correspondence to confirm their statements.)

Our analysis shows an average of 33.53 per cent as against a 40 per cent solution and a range from 25.42 to 39.15 per cent. This formaldehyde is unfit for use because there is no uniformity in strength on which to base a computation.

Two samples of formaldehyde were received from Medina said to have been purchased from the Jewett Drug Co., of Aberdeen, South Dakota. One was marked stock of 1903, the other fresh stock 1904. Our analysis showed these samples to contain:

	Formaldehyde.
Sample 1903	28.35 per cent
Sample 1904	28.35 per cent

This formaldehyde would be of no value as a smut killer according to the formula recommended by this station.

The following samples were drawn from stock purchased from the Dr. Geo. Leininger Chemical Co., of Chicago, as reported by the parties submitting the samples.

Where from. Retainer.	Per Cent.
Wyndmere, carboy	33.30
Fargo, bottle	37.91
Fargo, carboy	38.47
Milton, unknown	21.60
Neche, unknown	35.21
Oakes, bottled	30.37
Grafton, carboy	37.35
Oakes, unknown	30.71
Fargo, carboy	37.68
Fargo, carboy	36.78
Fargo, carboy	37.12
Fargo, carboy	36.45
Fargo, carboy	32.85
Fargo, carboy	33.07
Hillsboro, unknown	38.19
Duluth, Minn., carboy	27.45
Duluth, Minn., carboy	33.99
Duluth, Minn., bottle	31.16
Buffalo, unknown	33.75
Starkweather, unknown	28.46
Neche, bottle	36.73
Average	33.75

This shows an average of 33.75 per cent and a range from 21.60 to 38.47 per cent. A product so variable as this is proven to be is entirely worthless for use in treating wheat for smut. Farmers who use this formaldehyde will be pretty sure to be disappointed with the results, in fact the smut would not be killed by such a solution.

The claim has been put forth that on standing, formaldehyde loses strength. Our analysis does not confirm this opinion. In the summer of 1903 we analyzed a sample of formaldehyde from one pound bottle labeled the Heyden Chemical Works, Garfield, N. J.

This I found to contain 36.92 per cent. Since then the bottle has been standing in a warm place and recently it was re-examined with new solutions and by a different worker and the results reported were 36.68 per cent of formaldehyde, or but .24 of one per cent less than one year ago. Neither on the recent experiments reported by Professors Bolley and Manns confirm the claim of loss in strength on standing.

It seems to me that there is but one explanation to offer, regarding the Leininger formaldehyde, and that is gross carelessness in the factory and that there is but little checking up, or control of the work, in the factory. In February the manufacturers submitted a sample bottle of the formaldehyde stating this would be a fair average of the product which was to be shipped to the state. n this sample I found 39.37 per cent of formaldehyde and expected to find the product distributed in the state to be about the same strength.

SHORT WEIGHTS AND MEASURES.

Some of the difficulty is due to short weights and measures on the part of the druggists and others who have retailed the formaldehyde in the state. In some instances the carboy goods have been put up and sold in one and two pound bottles. Old beer bottles are not infrequently used for this purpose and the contents sold for two pounds. The average beer bottle found in the state filled well up to the neck I find to hold about 22 ounces by volume or slightly less than one and one-half pounds. Even were the formaldehyde of average strength this would mean the same as a 32 per cent formaldehyde of full measure. The farmer employing this would be disappointed for it would not make a solution strong enough to destroy smut.

Druggists and retailers in general are largely to blame for this condition as they must know that full measure is not given. It means discrediting the method and loss of future business to the house selling this class of goods.

A bottle sent in by one of the leading drug houses labeled with directions for treating the wheat recommended that the contents of the bottle (one pound) was to be used in 45 to 50 gallons of water. The bottle actually contained ten and one-half ounces by measure of 39.32 per cent solution of formaldehyde. The farmer who uses the product is sure to meet with disappointment. One prominent druggist recently admitted that more formaldehyde was frequently sold than purchased. There are but two ways by which this can be acounted for: short weights or measures and dilution. In either case the farmer is the loser.

CONFESSIONS OF A DRUGGIST.

In our efforts to get at the true inwardness of the trouble one prominent druggist gave us the following statement which may help to throw some light upon this mooted question.

"Many of the druggists of the state are dispensing a so called pound of formaldehyde in a Best tonic bottle and two pounds in a beer bottle. In other words less than 16 fluid ounces is sold as a pound while as a matter of fact a pound by weight occupies more than 16 fluid ounces space. The result is plain. From the druggists' standpoint it means the discrediting of formaldehyde as a smut killer and a consequent falling off in sales. From the farmers' standpoint they suffer in at least three ways by this short measure.

1st. They pay for a pound and get 10 ounces.

2nd. They use 10 ounces, believing it to be a pound and get a solution of so weak a germicidial strength as to be nearly worthless and lose their labor in applying it.

3. Much the most important of all they lose in smut laden crops where they have paid their money and expended their energies, believing that they have complied with all conditions necessary to "give formaldehyde a chance" and be rid of smut.

"Their natural and legitimate conclusions are that formaldehyde is no good. They have used it according to directions, they think, and failed to get results. From the papers and also from a circular received from you a few days ago I see you blame this failure to get results to under strength formaldehyde. Your conclusions are partly right, but I thought you ought to know the short weight fact (maybe you do) 12 ounces or three-fourths measure of 40 per cent means only practically the same as 30 per cent full measure and I don't believe the farmers add enough of these light weight pounds to make a solution of the desired strength to kill smut.

"Now I suggest that a circular be sent out to all the pharmacists of the state, telling them that an effort will be made to secure these light weight packages and if found the dispenser will be exposed unless he can prove that he has issued them in error.

"Now, professor, I expect you to acept this information in strictest confidence. Use your own judgment as to whether you act at all, or if so, what way. I request that no rumpus be made but that all be first given a chance to get into line. Then make it disagreeable for the crooks if you like.

"I am not giving this information for any other reason than to make and keep formaldehyde popular as an efficient smut killer."

REMEDY.

It is quite clear that manufacturers and druggists alike are responsible to a considerable extent for the discrediting of the formaldehyde method for destroying smut. I can see but one remedy and that lies in enacting a law which shall be strictly enforced, regulating the sale of formaldehyde. law similar to the fertelizer law, well enforced would put a stop to the present practices and ensure fair treatment for the farmer who is made to suffer heavy loss and the state loses many thousands of dollars each year by smutted wheat, which is entirely unnecessary since the farmers are doing their best to prevent this disease.

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NORTH DAKOTA.

Bulletin No. 61.

SCABIES IN SHEEP AND CATTLE AND MANGE IN HORSES.

By L. VAN ES.

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FARGO, NORTH DAKOTA, U. S. A.,
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SCABIES IN SHEEP AND CATTLE AND MANGE IN HORSES.

BY L. VAN ES.

Scabies or scab is a communicable disease of the skin produced by the presence and action of minute parasites, spoken of as mites.

The disease in sheep is one of the oldest known and its ravages were as formidable to the flock owner of antiquity as to the wool growers of today.

The actual cause of the disease, however, was not discovered until 1809, when Walz discovered the mite in sheep scab, which was followed in 1812 by Gohier's demonstration of the parasite of scabies in cattle.

The disease which has been the immediate cause af great losses to wool growers has a very wide distribution. Its ravages in this country, however, have been greatly diminished by the enforcement of intelligent sanitary regulations by the United States Department of Agriculture and the government of several states. Cattle scab, however, has only in the last years become generally distributed and now contributes a menace of more or less magnitude, not only to the cattle interests of the western ranges, but also to those of other states.

As mentioned before, scab or scabies is due to a minute mite. The disease in cattle and in sheep is due to the same species of animal, but the variety causing sheep scab is not parasitic in cattle, while the parasite producing scabies in the latter animels is harmless in sheep.

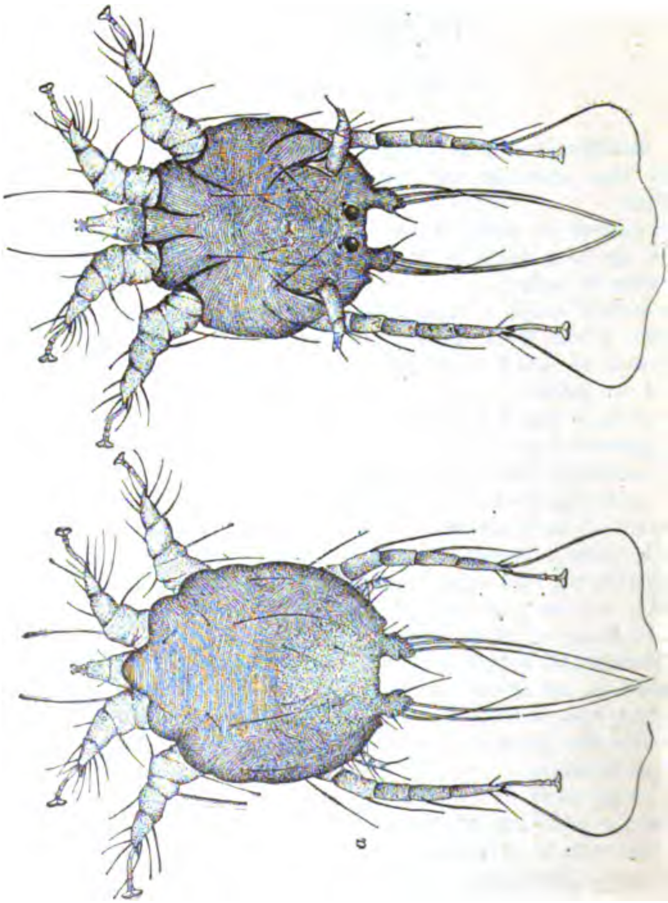
The scab mite is technically designated as Psoropter communis, while addition of the words "ovis" or "bovis" indicates whether the mite is parasitic on sheep or on cattle.

The name Psoroptes, derived from the Greek, implies that the parasites conceal themselves under the crusts and scabs, and in fact, they always remain on the surface of the skin and never burrow into its depths, as is seen in other forms of mange, which are met with.

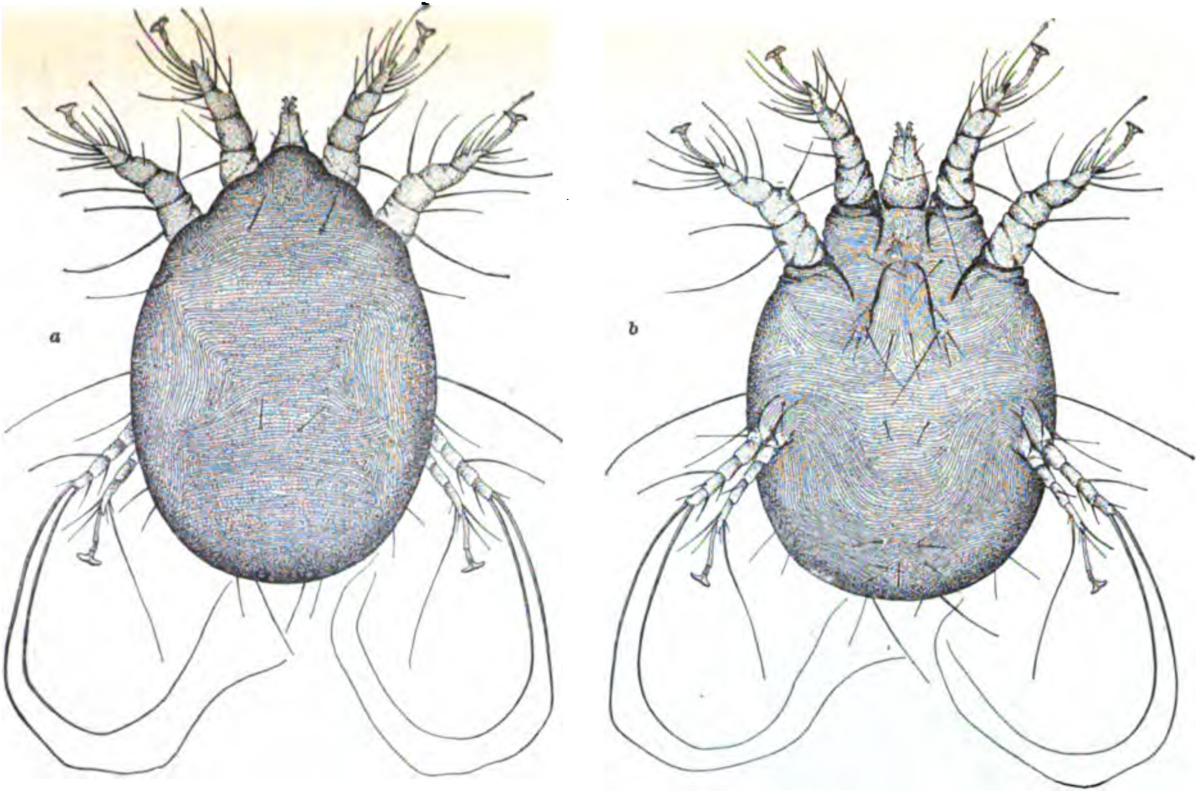
They prick the skin with their jaws in order to obtain blood or lymph as food and in this manner give rise to considerable irritation of the skin. The resulting inflammation leads to the crust or scab formation and the loss of hair to be mentioned later.

The mite of common sheep or cattle scab is characterized by its size, (under favorable conditions it can be recognized with the naked eye,) its eight long legs, head and jaws and finally by the presence of the terminal suckers on all the legs of the male, and on the first, second and fourth pair of the female.

The larva or undeveloped mite has three pairs of legs.



Figs. 1 and 2—Dorsal and ventral view of adult male of Psoroptes communis ovis. (Salmon and Stiles, B. A. I., Bull. 21, U. S. Department of Agriculture).



Figs. 3 and 4—Dorsal and ventral view of adult female of Psoroptes communis ovis (Salmon and Stiles, B. A. I. Bull. 21, U. S. Department of Agriculture.)

Their life history is about as follows: The females lay from twenty to twenty-four eggs from which the young larvæ develop in the course of from four to seven days. Those undergo three or four processes of moulting, and are full grown in from fourteen to seventeen days, when they are capable of reproducing themselves.

Gerlach figured out that one female in the course of three months may yield an offspring of one and one-half million mites, and Cooper Curtice regards this estimate as being very moderate.

The females die three to five weeks after laying eggs, while the males usually live to an age of six weeks.

In the presence of moisture, like manure, the mites remain alive for six to eight weeks and in dry air from two to three weeks. The eggs keep from two to four weeks in damp surroundings and from four to six days in a dry one. A moderate warmeth causes the mites to thrive and experience shows that they develop more rapidly in warm stables under cover and during warm weather.

The time between the first mite invasion and the appearance of symptoms varies according to the number of mites transmitted. When a large number are involved, symptoms of scabies may make their appearance in two weeks, when a smaller number of parasites gain a foothold from four to six weeks may pass before signs become visible.

The disease is communicated from animal to animal by means of direct contact or by intermediary bearers such as blankets, ropes, brushes or curry combs and attendants.

SHEEP SCAB.

Symptoms: The first indication of sheep scab is the intense itching. The animals scratch or rub themselves, and when they are scratched with a stick or otherwise, they will give plain evidence of satisfaction by pressing against the stick, by peculiar movements of the head, lips and tail, and by making an involuntary, scratching movement with one of the hind legs. The itching is most severe when the animals are warm, when they are in close sheds, during warm weather and after being driven.

The parts of the body most apt to become affected with common scab are those which are well covered by the fleece, which in case of scab infection becomes taggy in appearance. The animal's coat looks rough, small bunches of wool project from the surface and can easily be pulled off. The wool at those places is matted and stuck together by the dried secretion of the irritated skin. The rough condition of the coat is by no means improved by the rubbing and scratching alluded to above.

When, at the beginning of the disease the wool be carefully separated and the skin exposed, minute nodules of a pale yellow to reddish color indicate the places where the mite has bitten or punctured the skin. As the disease advances those nodules become very numerous, and they finally cover the entire area of the surface affected. In due course of time the nodules mentioned show at their summit a vesicle or pustule from which

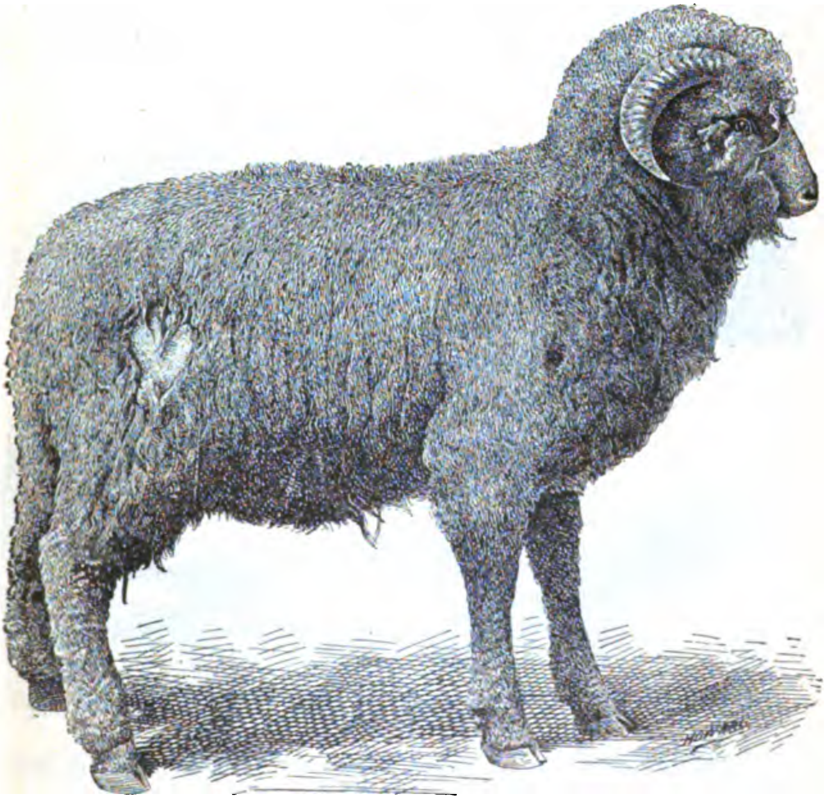


Fig. 5—Common sheep scab (early stage). (Salmon and Stiles, B. A. I., Bull. 21, U. S. Department of Agriculture.)

exudes a sticky fluid, which rapidly dries and adheres to the surrounding wool and epidermal scales and forms a hard and thick yellowish brown scab or crust. Under the influence of the irritation, the epidermis gives off a greatly increased amount of epithelial scales, which add to the scab formation.

The mites live and thrive beneath this crust and their activity continually adds to its thickness. When the disease advances the fleece presents a characteristic appearance; the wool is matted, rough and in some places the skin becomes completely denuded.

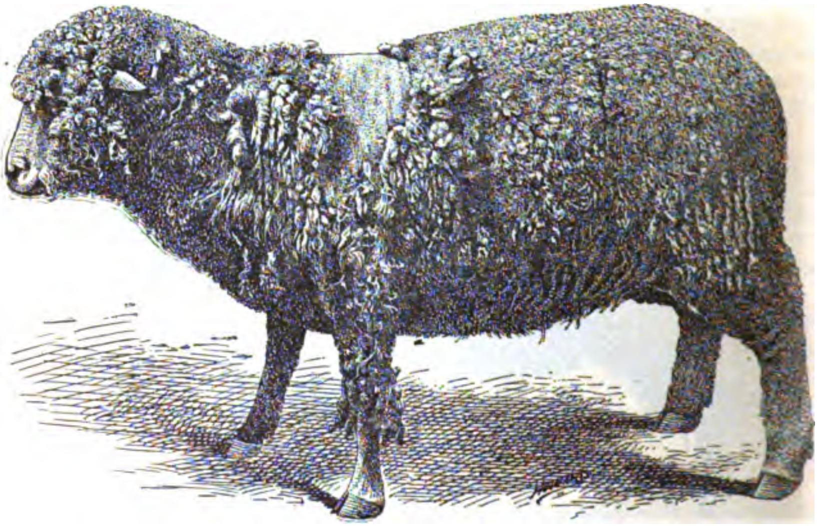


Fig. 6—Common sheep scab (more advanced). (Salmon and Stiles, B. A. I., Bull. 21, U. S. Department of Agriculture)

The denuded areas increase in size as the mites abandon the center and confine their activity to the periphery and the skin immediately around it. In the meantime the skin thickens, assumes the appearance of parchment and is marked by numerous folds or wrinkles.

In still later stages of the disease the different scabby areas become confluent, the skin is largely deprived of its natural covering, while the continued scratching and biting gives rise to inflammatory and ulcerative processes of a more severe nature.

Weak animals or such as are not well cared for show the physical effects of the disease in the form of loss of flesh, anaemia, and an increased weakness which may be the fore-runner of a fatal termination.

The symptoms of the disease are most pronounced during the fall and winter and are checked more or less by shearing.

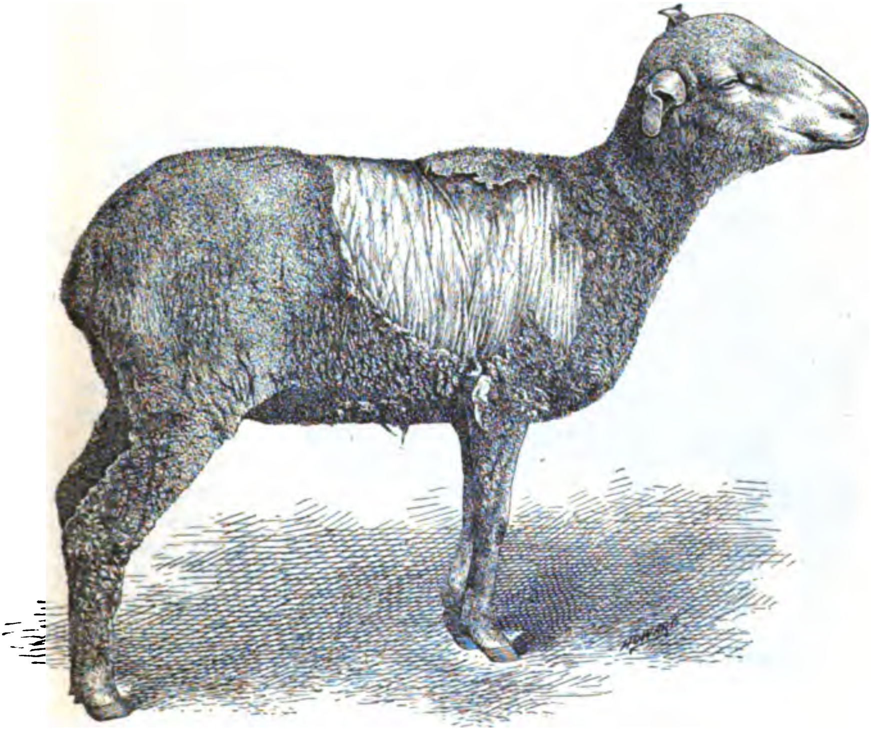


Fig. 7—Common sheep scab (showing large bare area after shearing). (Salmon and Stiles, B. A. I., Bull. 21, U. S. Department of Agriculture.)

Moussu makes the statement that when in a scabby flock of sheep only a number of animals are shorn, that there is a fair chance of them recovering, owing to the immigration of the mites to the animals which retained their fleece.

Diagnosis: While scab in sheep usually is quite typical in its manifestations and can be readily recognized, there are some other conditions, which may, for a time at least, be mistaken for scabies.

Sheep, which are exposed to continued rainy weather, may become affected with an eczema or skin eruption produced by the persisting soaking of the epidermis.

This affection, however, readily subsides when dry weather comes or when the animals are placed under shelter, and is not accompanied by itching.

Animals may also become affected by other parasites which produce intense itching and may lead one to suspect scabies. The more common parasites are the sheep tick (Melophagus ovinus) and lice (Trichocephalus sphaerocephalus), which can be readily recognized as the cause of trouble.

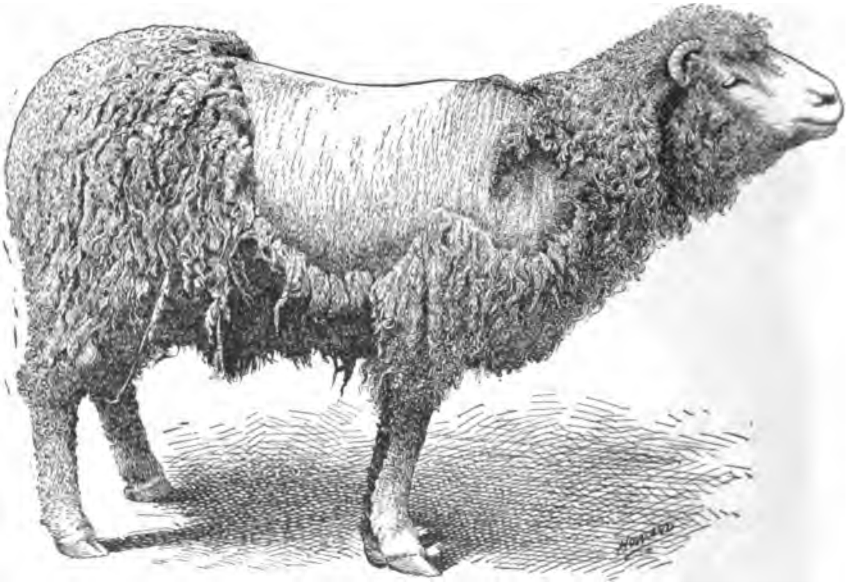


Fig. 8—Common sheep scab (advanced stage). (Salmon and Stiles, B. A. I., Bull. 21, U. S. Department of Agriculture.)

Another skin affection which is occasionally seen is spoken of as seborrhea and is caused by an inflammation of the sebaceous or oil glands of the skin. The disease is accompanied by itching, redness and tenderness of the skin and the presence of yellow or sticky secretion, which in severe cases, mats the fleece, parts of which may even be shed. While this last mentioned disease may at first sight be taken for scab, it can be readily distinguished from it by the smoothness of the skin and the diffuse redness.

The manner of diagnosis of scabies, however, which is the most certain and positive is the finding of the scab mite.

If a tuft of wool be pulled from the periphery of an affected area, placed upon a black piece of paper and kept in a warm place, a close observer will soon see small particles disengage themselves from the mass of wool and crusts. When those particles are examined with a magnifying glass they reveal themselves as the characteristic mite producing the disease.

Prognosis While cases of spontaneous recovery are said to have occurred, common experience teaches us that unless radical steps are taken, scab will go from bad to worse and produce losses varying from 10 to 80 per cent of the flock. If the proper treatment, however, be applied a cure may be effected.

Treatment: While treatment for scab usually is not thought of by flock owners until the disease has made its appearance, prevention should never be lost sight of.

The keeping of stock under the best possible sanitary conditions is of prime importance. Damp, unhealthy localities, or filthy and poorly ventilated sheds are favorable to the disease.

Poor individuals or lambs which are closely inbred not only contract the disease more readily, but they also succumb to it more quickly.

Cleanliness, well ventilated sheds, open air and sunlight, good food and water have a decided tendency to check the disease.

A most important factor in the prevention of sheep scab is the government supervision of the traffic in those animals at shipping points, stock yards. etc.

By the regulations of the Department of Agriculture, only sheep free from scab and not exposed to contagion can be shipped and by the continued enforcement of those rules, shippers are compelled not only to eradicate the disease, but the danger of a very prolific source of contagion, stock yards, stock cars, etc., is greatly reduced.

While the disease spreads most rapidly by direct contact of animals with one another, it must not be forgotten, that mites may be deposited in different places and retain their vitality for a long time when favorable circumstances are present. Cases are on record in which mites lived for six weeks after being removed from sheep and kept in a moist atmosphere.

The possibility of birds carrying mite infected scabs from place to place has been pointed out, and it is probable that such actually takes place in this disease as well as in a number of other communicable diseases.

Another factor in the prevention of scab is the widespread application of effective treatment of the disease. If every wool or mutton grower would see to it that scabby sheep are properly cured, the principal sources of infection would cease to exist and the ultimate eradication of the disease would soon be accomplished.

When, in spite of all precautions, scabies has gained a foothold among a flock, the question of cure must be considered.

The rational manner of treating scab effectually is by the process of dipping. This consists of the total immersion of the animals in a fluid or solution, which has the property of killing the scab mite. The mites once destroyed, the animals will soon regain their normal condition.

The selection of the proper solution or dip is a most important one. There are numerous preparations on the market, of which some are very good and of which others class with other patent medicines in being perfectly worthless. Another disadvantage of the proprietory dips is the usually high price, which, however, in sheep dipping is not felt as severely as in cattle dipping, when large quantities are to be used.

One of the most efficient and at the same time least expensive dips is the so-called lime and sulphur dip, which can be prepared by any one of average intelligence. The dip is a solution of a compound of lime and sulphur, (Penta-sulphide), which forms when the substances mentioned are boiled in water.

This dip has been well tried in Australia, South Africa and in this country and its use has been attended with general success. There has, however, been created some prejudice against its use by patent dip dealers and their agents, who claim that the lime and sulphur compound is injurious to the wool. Such, however, is not apt to occur, when the dip is prepared with care, and as most of the dipping is done shortly after shearing, it seems that there would be but little wool to be injured and that the resulting damage would be a trifle. Nevertheless it was deemed wise to make some observations on this subject. During last summer the flock belonging to the Experiment Station was dipped three times in the strong lime and sulphur dip used for cattle dipping. The first two dippings took place shortly after shearing, the last one when the fleece was one and one-half inches in thickness. Some time after the last dipping, samples were taken of the wool. One sample was sent to the North Star Woolen Mills of Minneapolis, and the other to the Bureau of Animal Industry, Washington, D. C., with the request of subjecting the wool to the most critical examination with a view of ascertaining if any damage had been produced by the dip. The following letter from the North Star Woolen Mills explains itself:

Minneapolis, Minn., Jan. 18, 1904.

Professor L. Van Es, North Dakota Agricultural College:

Dear Sir: We acknowledge receipt of your favor of the 13th inst., also sample of wool. The wool is of good character and well bred. We cannot notice any bad effect from being dipped. The wool washes out white, but is a little harsh which is the only fault we could find and this is not serious. The sample shows more strength of fiber than the average lots received. We shall be pleased to give you any further information desired.

Yours truly,
(Signed.) PARK W. PECK, Treasurer,
North Star Woolen Mill Co.

The Bureau of Animal Industry referred the sample sent them to a New England firm of wool dealers, from whom the following reply was received:

Washington, D. C., Jan. 29, 1904.

Professor L. Van Es; Agricultural College, N. D.

Dear Sir: In accordance with my letter to you of the 21st inst., I now have some data from New England with reference to the sample of wool which you sent to this bureau and which was forwarded to a leading manufacturer of wool fabrics at Sanford, Me. The expert there reports that, so far as he was able to determine with the naked eye, the dip had not injured the fiber in any way. He states that at first sight he thought perhaps it showed a little tenderness near the point, but after going into the matter further, and comparing it with undipped wools in stock, he reported that he could not see that it showed any less strength than wool which has not been dipped at all. The gentleman who had the sample in charge, with the desire to have corroborative judgment, took the wool to Boston and placed it in the hands of a gentleman whom he reports as an expert of the first rank. After examination, this expert says that "he could not see that the dip had injured the fiber at all." When asked if he did not think the top end of the fiber was not so strong as the other end, he replied, that all wools show less strength at this end than at the base. He considered "the wool all right in every way." The names of these experts are not in my possession, but I am assured that they have the entire confidence of the wool manufacturers of New England, and it is one of these manufacturers who has kindly given this information for this letter.

Respectfully,
(Signed.) D. E. SALMON,
Chief of Bureau.

From the above it would seem that lime and sulphur dip can be used with safety, if it is properly prepared and applied.

Lime and sulphur dip is being prepared according to quite a number of formulas.

The Bureau of Animal Industry recommends the following formula for cases of fresh scab:

Flowers of Sulphur, 24 pounds.
Unslacked lime, 8 pounds.
Water, 100 gallons.

This dip is also recommended when dipping is to be done as a precautionary measure.

In cases of very hard scab a stronger dip is to be recommended and the following formula known as the Fort Collins dip will answer the purpose:

Flowers of Sulphur, 33 pounds.
Unslacked lime, 11 pounds.
Water, 100 gallons.

Whatever dip is to be used the method of preparation is the same and in order to obtain good results, the following directions should be carefully followed:

Weigh carefully the amounts of lime and sulphur for the quantity of dip desired. Do not measure with a bucket or similar article or guess at the quantity, but weigh correctly.

The lime is now placed in a caldron or kettle and enough water added to slake it and form a paste. The sulphur is now added and the mixture is well stirred. Some authors recommend the sifting of the sulphur, but when a good quality of this chemical is obtained, this process may be dispensed with.

After the lime and sulphur are mixed water is added to the mixture in the proportion of about 25 per cent of the quantity of the ready dip.

The contents must now be boiled in order to bring about the chemical combination of the different ingredients.

The longer the solution boils the more sulphur will enter into the compound and the more effective the dip will be. When boiled for some time the mixture will become darker and finally will have the color of chocolate. In the opinion of the writer the mixture should be boiled for at least two hours, or at least until all particles of sulphur have disappeared. When this has been accomplished, the fluid should be allowed to settle, in order to eliminate the excess of lime, which should not be permitted to get into the dipping vat owing to its more or less caustic properties.

When the liquid is fairly settled the clear brown liquid may be drawn off into the dipping vat and enough water added to make the desired quantity of dip.

The dip when ready for use should be kept at a temperature ranging from 104 to 112 degrees as cold dips do not penetrate the wool and scab sufficiently, while hot dips are apt to have a weakening effect on the sheep.

The animals should be kept in the dip for two minutes by the watch, and in badly affected cases, they should be rubbed or scrubbed while in the solution. While the animal is in the vat the animal should be ducked at least once.

Diping should be repeated at an interval of from ten to twelve days. While the parasites are usually killed at the first dipping, it is possible that some of the eggs are not destroyed at that time and will in due time bring forth mites. Those should be attended to by a second dipping, before they are able to lay eggs themselves.

Of other preparations used for dipping the ones depending for their action upon tobacco, arsenic or creoline and its many imitations are the most commonly employed.

The scope of this publication does not permit the disucssions of those dips as we have in the lime and sulphur preparation one which is both economical and efficient. Speaking generally, the arsenical dips should be avoided, owing to their poisonous properties, while when tobacco dips are used a certain percentage of the nicotine should be insisted on. When a tobaco dip is ready for use it should contain from .05 to .06 of 1 per cent of nicotine.

The kinds of apparatus recommended and in use for dipping are as numerous as the preparations of dips on the market. Some flock owners prefer one kind and others another according to their individual taste and customs.

Two plans of apparatus may be considered, for the benefit of those who may be obliged to eradicate scabies from their herds or to dip as a precautionary measure.

The farmer with a small flock can get along with a simple vat, while those who have to dip several thousand head will need a more elaborate plant in order to do the work in a speedy and economic manner.

For a small industry any common tank will often answer the purpose. When it is, however, necessary to construct one, it is best to do so on special lines. By making the yat narrower on the bottom dipping fluid will be saved. The size of the vat depends somewhat on the breed of sheep to be dipped. The measurements range as follows: Width on top from one foot, nine inches to three feet, two feet being a fair medium. Width of floor from six inches to two feet, nine inches geing a good medium, length of vat fro msix to twelve feet.

In constructing a small vat a slanting end should be provided for in order to enable the animals to leave the dip by their own efforts.

It will be found convenient to sink the vat in the ground, allowing the top to project about nine inches.

The sheep are dropped in the liquid by hand, kept in for two minutes and are allowed to leave by the slanting end, where they can be held for a moment in order to drip or drain, thus saving dip.

For the purpose of dripping a specially constructed floor may be provided.

Small vats may be constructed of wood, galvanized iron or canvas. The latter is of advantage in the construction of portable vats.

When dipping has to be performed on a large scale, vats are needed which will hold many sheep at a time and which can be run through in rapid succession.

Vats of the ordinary breadth at top and bottom, but of greater length are used, so that a sheep in slowly swimming throug will remain in the fluid for a sufficient length of time. The length of such vats vary from 45 to 90 feet, some are made as a straight swim and others are doubled in order to save space and facilitate the heating.

The sheep are forced into the vats by means of chutes, while after leaving the liquid at the slanting end, they remain for a while on a wter-tight drinpping' floor, which drains into the vat

Such vats may be made of wood, concrete or galvanized iron. In order to facilitate cleaning one end should always be made a little lower than the other and be provided with a proper opening.

In the use of large vats, great quantities of dip are to be prepared and kept at the proper temperature. For this reason a plant should include a boiler and a mixing or preparing tank.

The lime and sulphur dip may be sufficiently boiled in a common wooden tank by leading live steam into it by means of a pipe. After boiling the fluid may be kept in the tank in order to settle.

SCABIES OR SCAB IN CATTLE.

Symptoms: In cattle the disease usually makes its appearance around the base of the tail, the sides of the neck and the parts immediately around the ears and the horns. In examining a skin recently affected by the disease, we find, at least when the skin is not too dark in color, the small points produced by the bites of the mite. These points gradually become more numerous and when they grow older are transformed in vesicles from which escapes a yellowish lymph which rapidly dries on the surface. The irritation leads to an increased desquamation of the surface epithelium and the shedding of hair. The epithelium, hair and abnormal secretion drying together in very dry, greyish-brown scabs.

Fig 10—Cattle Scab in Station Herd.

There is usually intense itching, the animals seldom allow the escape of an opportunity to rub themselves.

From the regions mentioned the disease rapidly spreads to other parts of the body, the back, sides, flanks, etc. The limbs are rarely affected, at least of the many cases seen by the writer on our western ranges and the few seen on the Experiment Station farm, the appearances of the legs always remained normal even in cases of which the other parts of the body were completely denuded.

The disease is more apt to become noticeable with the advent of cold weather and if left undisturbed will slowly extend over the larger portion of the body. Regions which were affected for some time are covered with a more or less thick dry crust, the removal of which discloses a thickened, roughened skin, which looks and feels like leather and is thrown in wrinkles and folds.

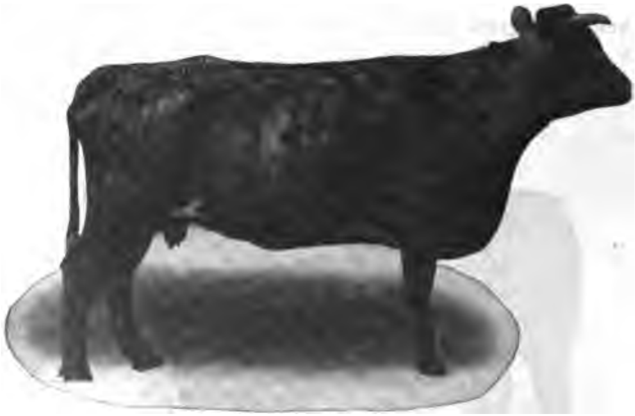


Fig 11—Cattle Scab in Station Herd.

The skin lesions are usually increased by the animals abrading the skin in their strenuous attempts to find relief from the intolerable itching.

They will rub against projecting objects until they bleed, making surface abrasions of some size. Those will often ulcerate, and with the blood and the scabs already present will give the animal a very loathsome appearance.

The surface wounds and ulcers may serve as an entrance of infections, which not uncommonly have a fatal termination.

As may be expected animals with marked cases of scabies are not apt to be very thrifty. The continued annoyance produced by the itching, the morbid changes in an important organ like the skin, tell on the general health of the animals. They lose flesh and if left alone will finally get in a condition of marked emaciation. Range animals which have to hustle for a living will not get the proper amount of food, as they are apt to stay around a post, fence or tree in order to find relief from the intense itching when they should be eating. Under the conditions present, the food thus obtained is not properly assimiliated owing to the great physical suffering to which the animals are subject.

Another factor, which tends to increase the losses from scab, is the loss of the normal coat of hair and its protection, so much needed in animals, which have to winter on our ranges.

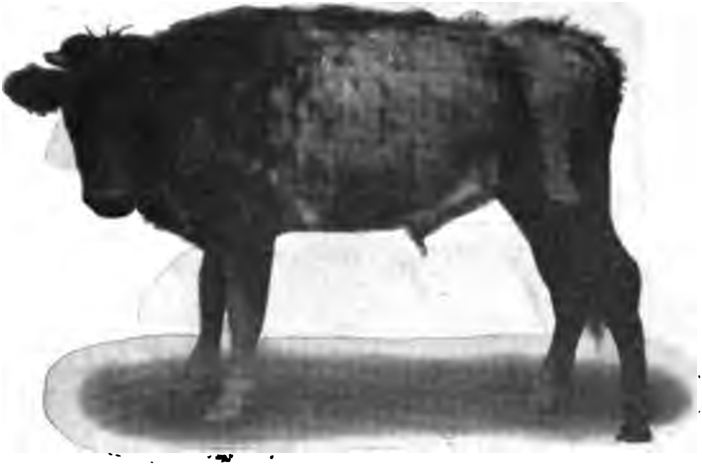


Fig. 12—Cattle Scab on the Range
(After a photograph by Dr. R. H. Treacy, Bismarck, N. D.)

The disease usually reaches its height in February, after which a general improvement may be observed provided the animal has a sufficient amount of vitality left. This improvement extends gradually until with the apearance of summer weather the animal has apparently recovered. Only apparently, however, as a close observer will notice that the rough coat and peculiar formation of the hair indicate something abnormal. In some cases the small abrasions produced by the bite may be felt through the coat. With the advent of the following winter, the usual symptoms will reappear with increased severity, as the parasites which have not caused much irritation during the warm weather again begin to attack the skin. This is a very characteristic feature of the disease.

Diagnosis: Certain conditions may be mistaken for scab and while this disease offers no great difficulties in diagnosis the symptoms of some other skin troubles may here be mentioned.

One of the most common ones met is "ringworm." It is a disease which is especially seen in calves and yearlings although frequently met with in grown cattle.

Ringworms usually ocur as round hairless areas, covered with a greyish-white crust. In the beginning these spots are clearly defined and occur more commonly on the head and neck of the animals. A very favorite place of this infection is the area surrounding the eyes which often leads to a very characteristic appearance of the animals.

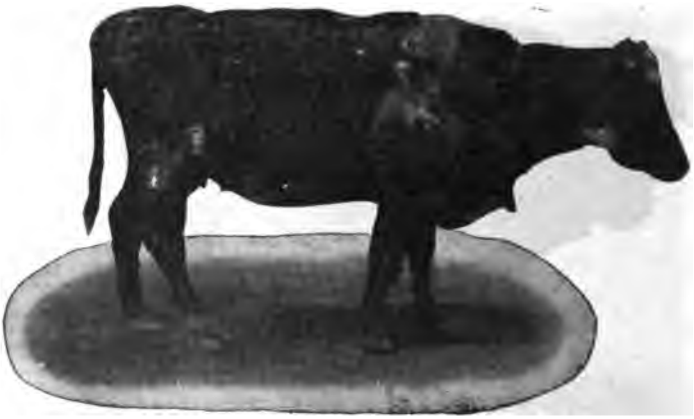


Fig. 13—Cattle Scab on the Range.
(After a Photograph by Dr. R. H. Treacy, Bismarck, N. D.

While some itching is frequently present, it is never as annoying as scab. Another point of difference is that ringworm usually does not extend over a large surface and is not subject to changes on account of warm and cold weather.

Lousiness may also lead to a suspicion of scab. There is intense itching and when the animals rub themselves a great deal, there may be a loss of hair with a roughness of the skin surface, but a close examination will soon reveal the true nature of the trouble. Occasionally a form of eczema is seen in range cattle which slightly simulates scab. The skin is scurfy, but the hair remains intact and itching is rare. It most frequently affects the skin of the croupe and back. The condition is perhaps due to filth, or to cold, wet weather.

The finding of the scab mite furnishes the best means of diagnosis. The presence of the parasite may be demonstrated as described in sheep scab, but as a rule the following method will yield better results, especially when the mites are not very numerous.

The skin of the suspected animal should be carefully scraped on the affected areas and when doing this it should be remembered that scraping from the periphery of a scabby patch are more apt to show parasites than those from the center.

In examing scrapings from genuine cases of scab, the writer has often failed to find the mite when the scabs were not taken from recently affected places.

After the scrapings have been collected, they are placed for a few minutes in a strong solution of caustic potash, which will dissolve the crusts or scabs leaving the parasites floating freely in the liquid. Some of the liquid may now be found on a glass plate and examined with a magnifier or low power microscope.

In the laboratory of the Veterinary Department of the Station the liquid is poured in a so-called Petri dish and examined with "2-3 objective and 1" occular.

It may be well to state at this place, that skin scrapings sent, prepaid, to the laboratory will be examined for residents of North Dakota and a report made on the result of the experiment without cost.

Treament: Like scabies of sheep, the disease in cattle can be treated successfully and in general the same plan should be followed, viz.: the dipping of affected or exposed animals.

The preparation recommended is also one of lime and sulphur, but the proportion of the ingredients is slightly different. The following formula has been used with excellent results by numerous observers:

Flowers of sulphur, 21 pounds.
Unslacked lime, 16¾ pounds.
Water, 100 gallons.

It is prepared in a similar manner as the mixtures recommended for sheep dipping. The required quantity is slaked and mixed with the sulphur. A quantity of water is now added and the mixture boiled until all the sulphur has been dissolved. After the settling of the liquid, the clear portion is drained into the vat and a sufficient quantity of water added to make the dip of the required strength.

In preparing the dip care must be taken that the ingredients are weighed properly and that the directions for preparing are carried out to the letter. Unfavorable results after the use of lime and sulphur dips can always be traced to errors in preparation and application of the mixture.

When engaged in the eradication of scab, thoroughness of method must be observed and not only scabby animals should be dipped but exposed ones as well. All animals should be re-dipped from ten to twelve days after the first application in order to destroy young mites which have hatched from eggs, which survived the first treatment.

In order to insure good results the dip liquid should be kept at a temperature of 102 to 112 degrees Fahrenheit. Cold lime and sulphur dips cannot be relied upon to cure scabies and no chances should be taken at poor results.

Cases of moderate severity or animals which were exposed to the contagion should be kept in the dip for two minutes, while bad cases should remain for three or four minutes. The head should be ducked at least twice and in very bad cases, the skin should be scrubbed with a stiff brush, while in the vat, in order to loosen the thick scabs and crusts.

When scabby cattle have been kept in sheds, stables or corrals, those structures should also be disinfected before the dipped animals are permitted to return.

This consists of the removal of all manure and the application of some mite killing preparation. The ooze or sediment obtained in preparing the dip may be employed for this purpose, and should be applied liberally. Another preparation recommended for disinfection is a 5 per cent solution of crude carbolic acid with enough lime to show where it has been applied.

Attention has recently been called to a certain sulphur bearing Texas oil as a cure for scabies. It has been tried by the United States Bureau of Animal Industry and the results have been quite promising. For the present, however, it seems wise to await the result of further experimentation before recommending its use.

This oil, which may be used as a dip, has the advantage of remaining in the coat of the animals for several weeks, not only doing away with the second dipping, but also safeguarding the animals against mite invasion as long as the oil remains.

The probable disadvantage of this material is its bulk, which would render its transportaion costly, and the danger of substitution of other oils by dealers.

The latter disadvantage may prove to be quite a serious one, as some oils contain substances which blisters the skin, a complication not devoid of danger.

It is needless to say that dipping should not be practiced during cold weather as the chilling of the animals may be accompanied by danger.

For the cases of scab which require treatment during severe weather, the process of "spotting" or "hand-dressing" is recommended. This consists of the application of remedies to the affected parts by means of a stiff brush. The materials used for this purpose are common lime and sulphur dip, a solution of sulphur in parafine oil or the sulphur bearing Texas oil, mentioned above.

"Spotting" or "hand-dressing," however, cannot be relied upon as a means of scab eradication, but is only recommended as a palliative measure during a season when dipping is out of the question.

While the principle of dipping in cattle is the same as in sheep, it is needless to say that the required aparatus for cattle dipping is somewhat different owing to the larger size of the animals.

Two kinds of dipping plants are generally in use. A small outfit for use of smaller industries, and a large swimming vat as would be needed, when cattle are to be dipped by the thousand.

The prevalence of cattle scab among the station herd during the winter of 1902-3 made dipping necessary during the spring. As conditions on the station farm are, in many respects similar to those of ordinary farms, an attempt was made to construct a plant suitable for smaller herds of cattle and to do so at a minimum cost.

Under certain circumstances, a transportable plant may have advantages, and in order to ascertain the practicability of such a plant, an attempt was made to construct one. The plant devised and used in this experiment can be made at a cost of about $70, and includes a canvas tank lowered in the ground, a derrick, a cage, dripping floor and block and tackle.

The general working plan and construction is shown in Figs. 14, 15, 16, and 17, while the following material was used.

1 Canvas tank 4 x 7 x 10 feet, (manufactured by Beck and Wright, Moorhead, Minn.)

DERRICK.

2 Pieces 6' x 6', 20 feet each.
1 Piece 6' x 6', 10 foot.

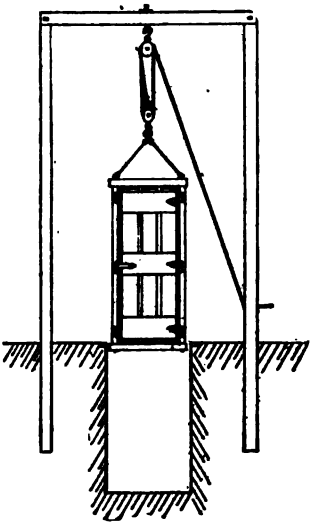


Fig. 14—Station Dipping Plant. Construction of Derrick, Block and Tackle and Cage.

CAGE.

6 Pieces 4" x 4", 7 feet each.
6 Pieces 4" x 4", 4 feet each.
13 Pieces 2" x 6", 9 feet each.
24 Pieces 10" x ¾", 6 feet each.

75 " Iron rod, ¼".
3 Pair hinges.
2 Pair clasps.
12 Bolts, 8½" x ½".
5 Pounds nails.

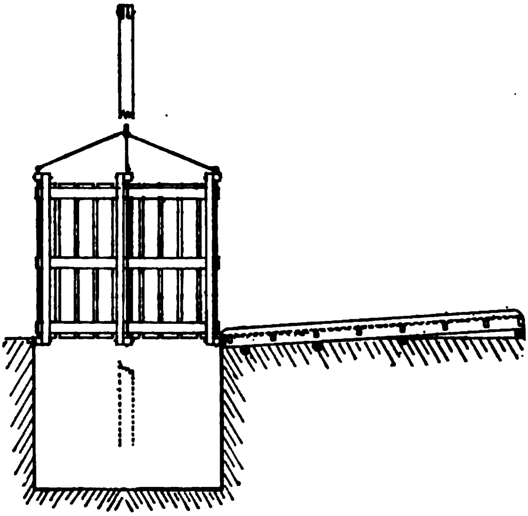


Fig. 15—Station Dipping Plant. Side View of Cage, Derrick, Tank and Dripping Floor.

SLIDE OR GUIDE.

4 Pieces 4" x 4", 2½" each.
16 Small posts, 3" each.
8 Pieces, 2" x 4", 1½" each.
4 Pieces, 2" x 4", 2" each (oak.)
8 Bolts, 3½" x ⅜".
1 Pound nails.

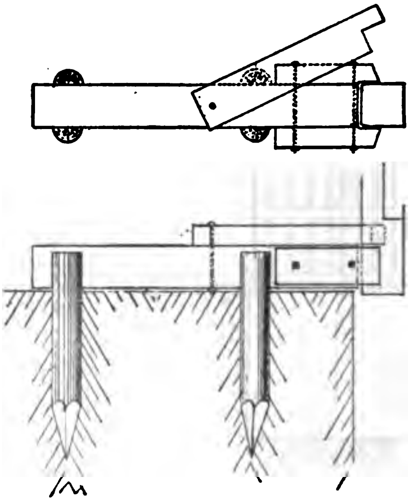


Fig. 16—Station Dipping Plant.
Construction of Guiding Slide and brake.

DRIPPING FLOOR.

2 Pieces, 6" x 2", 14' each.
8 Pieces, 2" x 4", 3½ feet each.
14 Pieces, 4" matched flooring, 14 feet each.

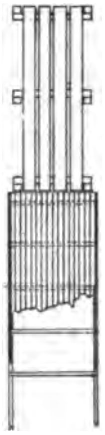
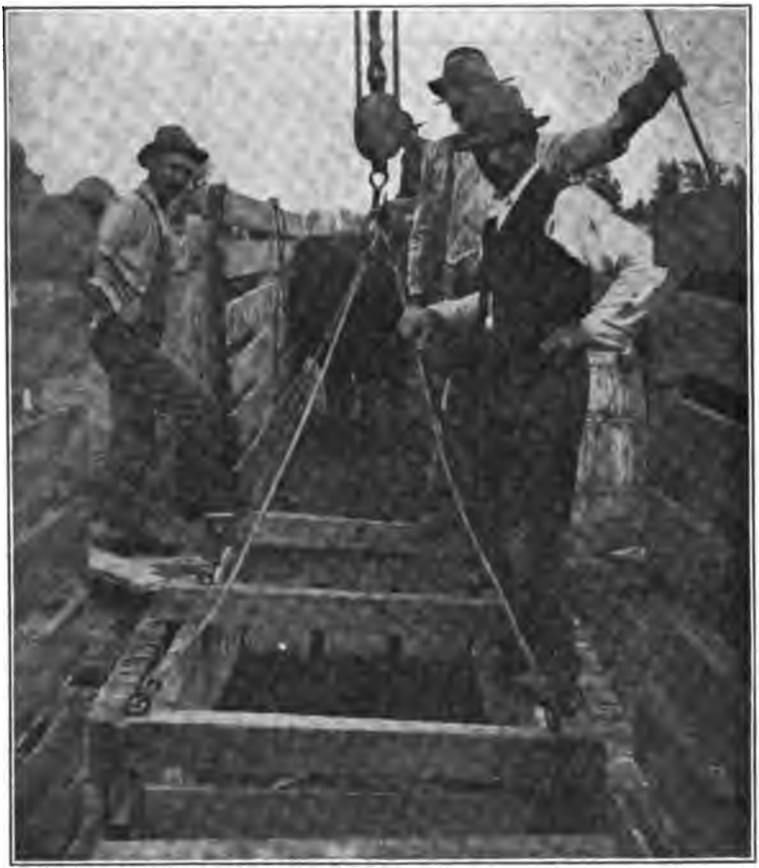


Fig. 17—Station Dipping Plant.
Construction of Cage Floor and Dripping Floor.

BLOCK AND TACKLE.

1 8" double sheave block.
1 6" single sheave block.
1 6" sheave.
100ft. 1" rope.



Station Dipping Plaut.
Cage in Vat. Shows Method of Fastening Canvas Tank.

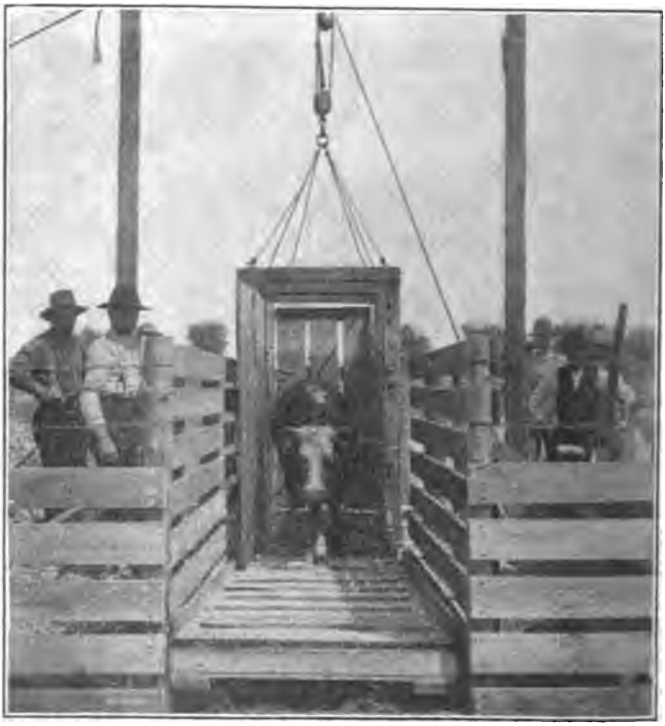


Fig. 20 – Station Dipping Plant.
Animal Emerging from the Cage.

The plane just described has rendered good service in treating scabies at this Experiment Station, and is so constructed that it can be readily taken apart and transported.

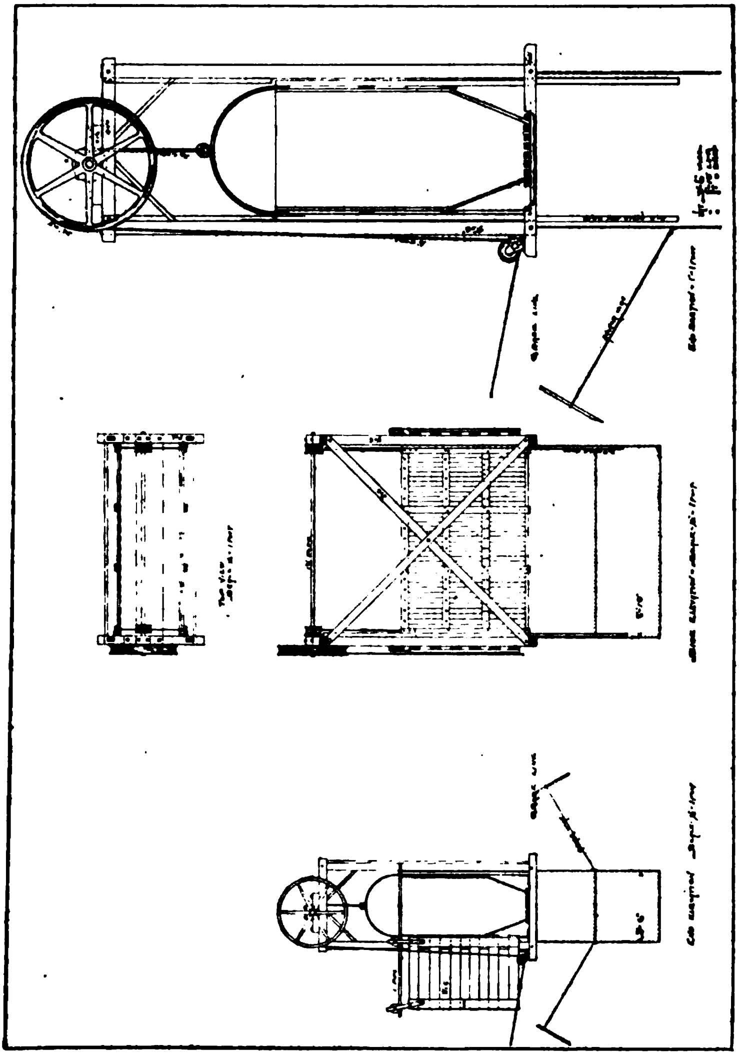


Fig. 21 - Small Dipping Plant (Courtesy of C. A. Newberry, Manufacturer, Alliance, Neb.

When a more permanent apparatus is desired, the one illustrated on Plate No. 21 is to be recommended. It consists of a galvanized iron tank and a cage moved up and down by means of a windlass. This plant is patented by C. A. Newberry, a manufacturer of dipping machinery of Alliance, Nebraska, and its price is listed at $135.00.

The contrivances just described work slower than the swimming vats, in which several animals may be dipped at the same time, but the writer feels justified in recommending their adoption when less than 1,000 head have to be dipped. Two hundred head may be dipped during the day.

It has the advantage that the animals can be handled more gently and that they are under perfect control while in the vat. As it is essential that the dip be kept at the required temperature, some provision for this purpose is to be made. The dip may be heated in two ways. In one the heat is derived from the steam of an ordinary boiler, and in the other a special heating apparatus is attached to the diping vat. When a boiler isused the steam is simply allowed to escape to the dipping vat. When a boiler is used the steam is simly allowed to escape into the liquid by means of a hose or pipe.

The special heating apparatus spoken of consists of a pipe running alongside of the vat and communicating with it below and above. The pipe is provided with several elbows by means of which a straight piece is placed parallel to the vat, at some distance from it, in an open trench. In this trench a fire is maintained and the whole arrangement is so made that the pipe is well surrounded by the fire. As the pipe slightly inclines, the heated water escapes upward into the vat, while its place is taken by colder water entering the pipe from below. The water thus being kept in circulation, gradually reaches the required temperature. Instead of a single pipe, a coil of pipes may be used, by which arrangement a greater surface is exposed to the heat of the fire and the required temperature can be obtained in a shorter space of time.

The same fire may be made use of to prepare the dip by placing the tank in which this is to be boiled over the trench.

For the dipping of large numbers of range cattle a large swimming vat is to be preferred. Such a vat may be constructed from wood, galvanized iron or stone. Galvanized iron or stone vats are perhaps the most durable. The iron vat especially has great advantages in being light in transportation and may be kept absolutely water tight. Stone vats are only adapted to places where the material is abundant and does not have to be hauled any great distance. In building stone or brick vats, the effect of the severe freezing weather in our state must be taken into consideration. The vats are made of different lengths; from 30 feet to 100 feet constituting the usual length. For work on our ranges a vat of not less than 65 feet is to be recommended. The depth of a swimming vat is seven feet, while the width on top is 46 inches and at the bottom 18 inches.

The cattle enter the vat from a chute and are forced into the liquid by means of a trap or a slide, the latter to be preferred as being less liable to get out of order. If necessary the animals may be kept in the dip by means of a sliding gate. After they have remained in the vat for the required amount of time they leave by means of the incline at the end of the tank. From the tank the cattle enter upon the dripping floor or chute from where the dip which is carried out of the vat in the hair of the animals is again conveyed into the tank.

A dipping plant intended for the dipping of large numbers of cattle should include pens or corrals for holding the cattle, the size of which may be based on the number of cattle to be handled.

A large plant may be heated on the same principle as a small one. When using a pipe system, it seems essential that a set of pipes be provided for each side, as otherwise too much time may be involved in heating the liquid.

For the general plan of construction of dipping plant, heating apparatus and details of galvanized iron tank, the reader is referred to Figs. 22, 23 and 24.

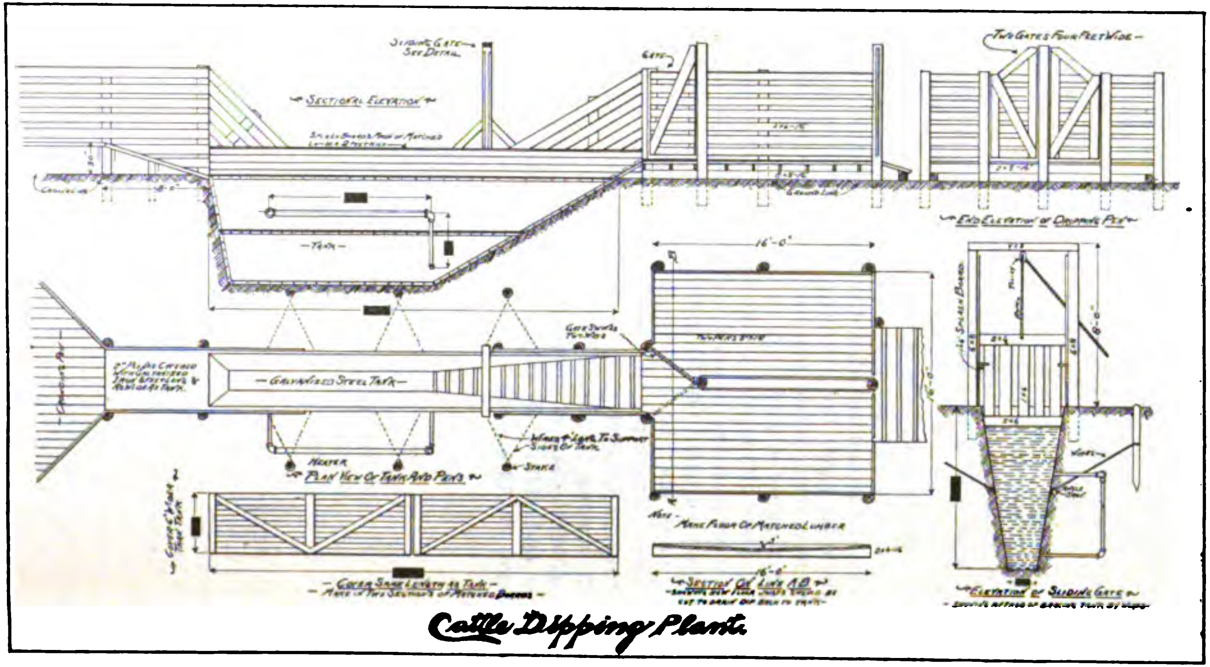

Sliding Gate
See Detail
Sectional Elevation
Sides Boards Made of Matched Lumber & Plastered
3'0"
Concrete
18'-0"
Tank
Gate
Two Gates Four Feet Wide
Ground Line
End Elevation of Dripping Pen
16'-0"
2" Planks Covered With Galvanized Iron Sheet Cleats & Nailed to Plank
Galvanized Steel Tank
Gate Swung Two Ways
Dripping Pen
Wires & Legs To Support Sides Of Tank
Heater
Stake
Plan View Of Tank And Pens
Cover 6' Wide Over Tank
Cover Same Length as Tank
Made in Two Sections of Matched Boards
Note -
Make Floor Of Matched Lumber
16'-0"
Section On Line A B
Splash Board
8'-0"
Elevation Of Sliding Gate
Cattle Dipping Plant.

Fig. 22—General Plan of Large Dipping Plant. (Courtesy of C. A. Newberry, Alliance, Neb.)

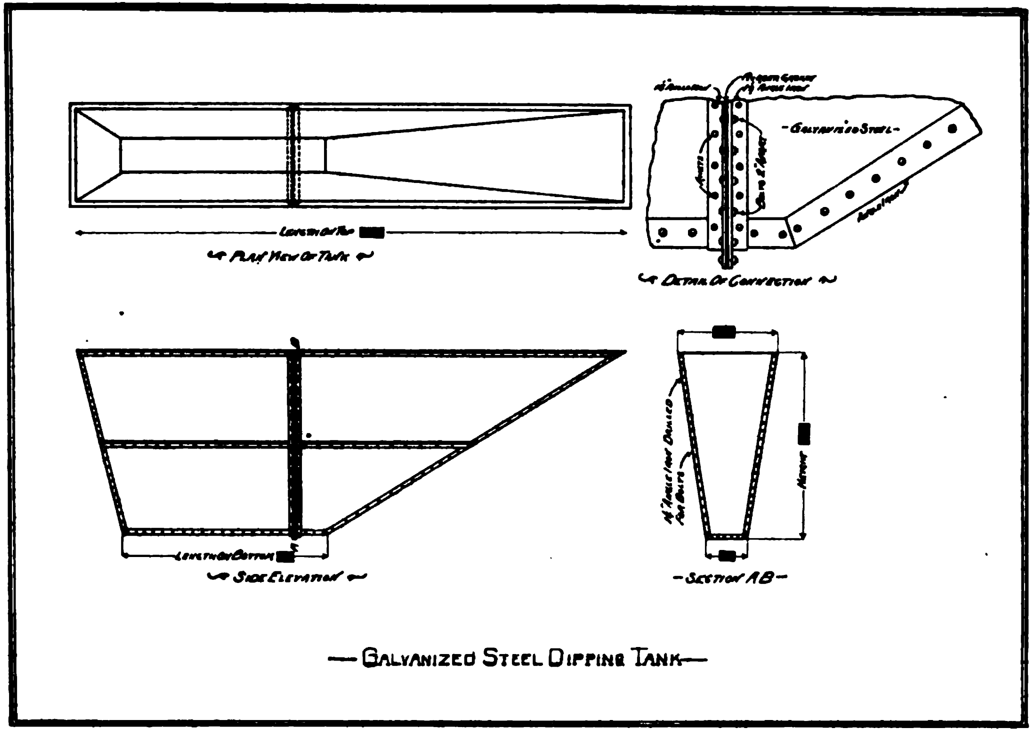


Fig. 23—Detail of Construction of Galvanized Steel Dipping Vat. (Courtesy of C A. Newberry, Alliance, Neb.)

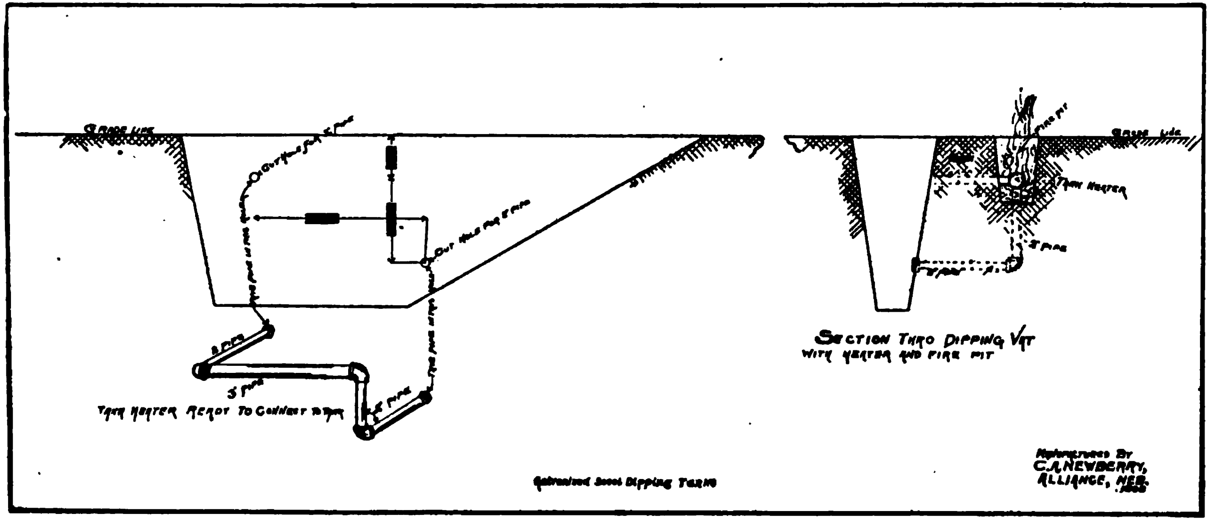


Fig. 24—Heating Plant for Dipping Vat. (Courtesy of C. A. Newberry, Alliance, Neb.)

MANGE IN HORSES.

While mange of the horse is not near as common a complaint as scabies in cattle and sheep, there have come to the notice of the writer a sufficient number of cases to warrant a description of the disease in this publication.

Like scab in other farm animals, mange in the horse is also caused by a small parasite. This parasite (Sarcoptes scabies,) simulates in many respects the common scab mite, but is spscifically different. Instead of remaining on the surface like the Psoroptes, the Sarcoptes mite has a tendency to burrow into the epidermis or into the crusts formed on the infected skin. It is very small so that it cannot be seen with the naked eye and may be distinguished by its turtle like appearance and its short legs, when seen under the microscope. The first evidence of their activity is a very intense itching. During the earlier stages of mange, a horse will make the most desperate efforts at rubbing itself against objects near by. When the affected areas of the skin are touched or scratched with one's hand, the animal will give signs of pleasure and satisfaction by pressing against the hand and by the very characteristic movements of lips and nose.

The itching sensation is most intense at night and when the animal is placed in a warm stable.

The disease may make its appearance on any part of the body, which was first invaded by the parasite, but in most cases the head and the sides of the neck are apt to show the disease earlier than other regions of the body.

The lesions of the skin consist of very minute papules on which the hair is loose, lost or matted together by a sticky fluid. A little crust forms about those places; this can be readily removed by the finger nails, leaving small, moist and denuded surfaces. As the disease progresses the denuded areas increase in size, become covered with crusts and in course of time extend over the largest portion of the body. The crusts gradually increase in thickness and give the animals a very loathsome appearance. The skin is now greatly thickened by the constant irritation and inflammatory conditions, which are increased in severity by the efforts of the animal while trying to find relief from the terrible itching bv rubbing and gnawing itself.

Animals thus affected gradually lose flesh, become weak and unless properly cared for will finally succumb to a state of emaciation.

The disease is slow in its course and some time may elapse before the real trouble is diagnosed.

The diagnosis of this disease, especially in its early stages is not always easy as the mites may readily escape observation. The intense itching and the apparently slight lesions at the beginning of the disease, should always lead one to be suspicious.

The difficulty in diagnosis may be overcome by the microscopic examination of skin scrapings and the demonstration of the parasitic mite.

Owing to the burrowing tendencies of the mite, the scrapings should be made deeply even down to the blood, as otherwise the parasites may entirely escape attention.

The chances of recovery from this disease are fairly good in recent and slight cases. In cases of long standing in which the larger portion of the body is affected the prognosis is decidedly bad and it takes a good horse to be worth the treatment.

The treatment consists of the careful removal of the crusts on skin and hair. A good way to accomplish this is by an application of common German soft soap. This is thickly rubbed over the affected areas and left for a few hours, when it will be found that the scabs can be readily scrubbed and washed off.

After this the skin is allowed to dry and a mite killing preparation is applied.

The ordinary acaricides, such as lime and sulphur, sulphuretted potash, tobacco, etc., will answer for this purpose. The following preparation may also be recommended. It consists of one part of creoline, (or one of its many imitations, now on the market.) and sixteen parts of raw linseed oil. It must be applied after the skin has dried and should it be necessary that the larger portion of the body surface should be included in the treatment, it is advisable not to cover the whole area with the oily mixture at one time, as such a procedure may interfere with the normal excretory functions of the skin. Cover a certain part of it every day until the whole surface has been treated.

The treatment should be persisted in for some time and as soon as the irritation and itching have subsided, the skin may be washed with soap and water. The case should now be carefully watched for the possible return of the old symptoms. Should this occur the same treatment must again be applied. Recurrance of mange after treatment is by no means uncommon and should not cause too great a disappointment to those undertaking the treatment.

Some authors recommend the dipping of horses, but it seems doubtful that the short time during which the skin is exposed to the dip is sufficient to bring about the destruction of the mites owing to their burrowing habits. Several applications of materials which adhere to the skin for some time will yield better results. This, aside from the fact that horses as a whole do not take kindly to dipping as cattle and sheep.

When dealing with horse mange the possibility of prevention must not be lost sight of. Horses with skin lesions simulating those of mange should be kept apart from other animals. Curry combs, brushes, blankets, harness, etc., used on affected or suspected animals should not be used on healthy ones, unless previously disinfected. This can be done by submersion in a warm 5 per cent solution of carbolic acid, to which a smlal quantity of soda has been added.

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NORTH DAKOTA AGRICULTURAL COLLEGE

Government Agricultural

Experiment Station

OF

NORTH DAKOTA.

Bulletin No. 62.

WEED STUDIES

Buried Weed Seed,
Notes on French Weed,
Quack Grass,
Canada Thistle and Sow Thistle.

By L. R. WALDRON

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

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November, 1904.

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WEED STUDIES

BY L. R. WALDRON.

VITALITY AND GROWTH OF BURIED WEED SEED.

SUMMARY.

From this experiment, the most important conclusions to be drawn are:

1. Small weed seed, the size of naked timothy seed, will not come up ordinarily through two inches of soil. Includes, shepherd's purse, tumbling mustard and pepper grass.

2. Frenchweed seed (Pennycress) comes up abundantly through one inch of soil, unwillingly through two inches of soil and not at all through three inches.

3. Green Foxtail (also Yellow Foxtail) germinates about May 1 and does not germinate in the fall from seed gathered that season.

4. Wild mustard seed comes up most abundantly through one inch of soil, very abundantly through two inches, abundantly enough through three inches and not at all through five inches.

5. Wild Mustard and Frenchweed seed will not be preserved in the soil for a period of years unless deeper than three inches.

6. Kinghead (Great Ragweed) grows better when planted two and three inches deep, than one inch, and it will come through five inches of soil.

7. Kinghead grows more abundantly the second, than the first year, after planting.

8. Wild Buckwheat comes up readily through one, two and three inches of soil. (No seedlings after first pulling).

9. Wild Oats will come up through five inches of soil.

10. Wild Buckwheat was entirely dead when buried twenty months.

11. Wild Oats was practically dead when buried twenty months and entirely dead when buried fifty-six months.

12. Shepherd's Purse, Green Foxtail and Kinghead were practically dead when buried fifty-six months.

13. Wild Mustard and Frenchweed has good germination after being buried fifty-six months.

14. The deeper buried seeds are better preserved. This holds true up to a depth of ten inches.

DETAILS OF EXPERIMENT.

So many inquiries have been received regarding weed seed; the length of time they will live in the soil, through what depth of earth they will come after germinating, to what depth it is necessary to summer fallow to obtain a clean seed bed, etc., that it was deemed wise to carry out work looking toward the solution of some of these problems. In the fall of 1899, Professor H. L. Bolley outlined an experiment regarding buried weed seed, the details of which were carried out in large part by the author.*

Seven beds, each measuring 3½ by 8½ feet, which had been in sod seven years, were put in good tilth, most of the sod roots being removed. The beds were enclosed by six inch boards and the surface of the beds raised three or four inches above the surrounding ground. The soil was of the ordinary black alluvial loam. During the first two years the beds were affected to a greater or less extent by water running near them which had been pumped from a cess pool. Whether this water had a material effect upon the seeds in the beds and consequently upon the experiment, it is impossible to say.

Seven kinds of weed seed were used, one kind for each bed. In each bed six (short) rows of seed were planted, at depths of one, two, three, five, seven and ten inches respectively. The seeds were so placed as to be in normal soil conditions, yet so that part of the seeds could be removed without disturbing the remainder. Glass strips were buried in the ground at the depth of the different rows in order to locate the seed.

The kinds of seed used were: Shepherd's Purse (*Bursa Bursa-pastoris*), Frenchweed (*Thlapsi arvense*), Green Foxtail (*Chaetochloa viridis*), Great Ragweed or Kinghead (*Ambrosia trifida*), Wild Mustard (*Brassica arvensis*), Wild Buckwheat (*Polygonum convolvulus,*) and Wild Oats (*Avena fatua*).

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*For previous notes upon this experiment, the reader is referred to the tenth, eleventh and twelfth annual reports of this Station. The notes there given, are embodied here.

The seed was freshly gathered and properly dried and certainly viable though some showed low germinating power in the germinator probably because not yet "mature." An abundance of seed was planted in each row, but each row of any one bed received practically the same number of seeds.

The following shows the growth made during the fall of 1899, after October 17:

Shepherd's Purse—

1 inch seeding, few plants.
2 inch seeding, few plants.

Frenchweed—

1 inch seeding, 25 plants.

Wild Mustard—

1 inch seeding, 435 plants.
2 inch seeding, 300 plants.
3 inch seeding, 40 plants.

Wild Oats—

1 inch seeding, 27 plants.
2 inch seeding, 16 plants.
3 inch seeding, 6 plants.

These seedlings were clipped off Nov. 25, and no further growth occurred that season nor was any observed in the remaining beds.

GROWTH DURING 1900. On April 7, the one inch seeding, in the beds of Shepherd's Purse, Frenchweed and Wild Mustard showed extensive germination. By April 21, a few seedlings of the one inch seeding of Kinghead and Wild Buckwheat had appeared and at that time a few seedlings of the two inch seeding of Frenchweed and Wild Mustard were above ground. Foxtail and Wild Oats were not yet in evidence. By April 28, a few seedlings of the one, two and three inch seedings of Wild Oats were above ground. On May 5 the Foxtail of the one inch seeding was just sprouting and by that time Kinghead and Wild Mustard planted three inches deep were above ground.

On May 12, the seedlings were pulled and counted, the number being shown below. If a depth of seeding is not mentioned, it is understood that no seedling came through that depth.

Shepherd's Purse—
1 inch seeding, 3240 plants.

Frenchweed—
1 inch seeding, 783 plants.
2 inch seeding, 16 plants.

Green Foxtail—
1 inch seeding, 1104 plants.
2 inch seeding, 366 plants.

Kinghead—
1 inch seeding, 100 plants.
2 inch seeding, 217 plants.
3 inch seeding, 91 plants.

Wild Mustard—
1 inch seeding, 730 plants.
2 inch seeding, 635 plants.
3 inch seeding, 290 plants.

Wild Buckwheat—
1 inch seeding, 137 plants.
2 inch seeding, 64 plants.
3 inch seeding, 80 plants.

Wild Oats—
1 inch seeding, 43 plants.
2 inch seeding, 31 plants.
3 inch seeding, 40 plants.

On June 5, 1900, the following pullings were made:

Shepherd's Purse—
1 inch seeding, 70 plants.

Frenchweed—
1 inch seeding, 2 plants.

Green Foxtail—
1 inch seeding, 190 plants.
2 inch seeding, 140 plants.
3 inch seeding, 169 plants.

Kinghead—
1 inch seeding, 2 plants.
2 inch seeding, 1 plant.
3inch seeding, 12 plants.
5 inch seeding, 9 plants.

Wild Mustard—
1 inch seeding, 20 plants.
2 inch seeding, 19 plants.

Wild Buckwheat—None.

Wild Oats—
1 inch seeding, 23 plants.
3 inch seeding, 13 plants.
5 inch seeding, 6 plants.

On August 28, 1900, there were pulled:
Frenchweed—
1 inch seeding, 164 plants.

On June 13, 1901, twenty months from sowing, the following seedlings were pulled:

Shepherd's Purse—
1 inch seeding, 47 plants.

Frenchweed—
1 inch seeding, 54 plants.
2 inch seeding, 13 plants.

Green Foxtail—No plants up.

Kinghead—
1 inch seeding, 25 plants.
2 inch seeding, 116 plants.

3 inch seeding, 29 plants.
5 inch seeding, 14 plants.

Wild Mustard—No plants up.

Wild Buckwheat—No plants up.

Wild Oats—
2 inch seeding, 8 plants.

On Oct. 7, 1901, the following growths were noticed which were the last:

Wild Mustard—1 plant from a depth of 3 inches.

Kinghead—1 plant from a depth of 5 inches.

RECORD OF GERMINATION OF SEEDS DUG AND TESTED IN THE LABORATORY: A number of each of the different kinds of seed buried to a depth of seven and ten inches were dug up June 13, 1901 and tested in the laboratory for viability, ability to grow. In case of most of the seeds, a definite number were counted out and the percentage of growth determined. Besides this, a mass of seeds and dirt were placed in the germinator and the total number of germinations noted. The seeds of Shepherd's Purse were too small to allow percentage determination.

SHEPHERD'S PURSE: Eight germinations noted from a mass of seed found in ten inches of row buried seven inches. Seventy-six germinations noted from the mass of seed found in ten inches of row buried ten inches.

FRENCHWEED: Five germinations noted from the mass of seed found in ten inches of row buried seven inches. Counted out twenty-five seeds and tested separately. Percentage germination, zero.

Fifteen germinations noted from the mass of seed found in ten inches of row buried ten inches. Percentage of germination, 4; that is, 4 per cent grew. These seeds were probably not mature when tested.

GREEN FOXTAIL: Some of these seeds buried seven and ten inches were germinating when taken up. Two hundred eighty germinations from the mass of seed in ten inches of row buried seven inches. Percentage germination, 29.

One hundred forty-one germinations noted from the mass of seed in ten inches of row buried ten inches. Percentage germination, 17.

Kinghead: Seeds not tested in mass. Seeds examined and about 25 per cent not rotted and contained plantlet. Percentage germination of seeds buried seven inches equaled 8. Percentage germination of seed buried ten inches equaled 20.

Wild Mustard: Some of the seeds buried seven and ten inches were germinating when taken up. Sixty-three germinations noted from the mass of seed found in ten inches of row buried seven inches. (Possibly some of the seeds not taken up). Percentage germination, 71.

Two hundred ninety germinations noted from the mass of seed in ten inches of row buried ten inches. Percentage germination, 16.

Wild Buckwheat: Examined over 250 seeds buried seven and ten inches and found the endosperm and germ rotted in all of them. No germination.

Wild Oats: Dug ten inches each of rows of seeds buried seven and ten inches, and found some germinating in each row. About 80 per cent of the seeds either rotted or previously germinated. Counted out twenty-five seeds and tested with no growth.

GERMINATION TESTS IN 1904

The foregoing tests were made in June, 1901, and no further tests were made until June, 1904, nearly five years after the experiment was started. At this time it was not possible to find any seeds in the one and two inch seedings; all were grown or decayed. Here follows germinations tests of these:

Shepherd's Purse: One growth each from mass of seed buried five and ten inches. Unable to distinguish seeds.

Frenchweed: Over 200 seeds counted out and left in the Geneva germinator over three weeks with no growth whatever. Some of these seeds were saved, dried and three months later were tested again. At that time the seeds grminated nearly 90 per cent. Evidently very few of the seeds had rotted or germinated.

Green Foxtail: Most of the seeds rotted or previously germinated. Seeds buried five inches, one germination from twelve seeds. Seeds buried ten inches had a percentage germination of 6 2-3.

Kinghead: In nearly all cases where seed was found, the outer envelope (involucre) had rotted away and in some cases even the embyro was laid bare. This looked healthy in many cases. Most of the seed had evidently grown or decayed.

3 inch seeding, 2 seeds, no germination.
5 inch seeding, 16 seeds, no germination.
7 inch seeding, 39 seeds, no germination.
10 inch seeding, 15 seeds, 4 germinations.

WILD MUSTARD:

3 inch seeding, 15 seeds, 4 germinations.
5 inch seeding, 100 seeds, 16 per cent germinated.
7 inch seeding, 100 seeds, 27 per cent germinated.
10 inch seeding, 100 seeds, 41 per cent germinated.

It is quite possible that a larger percentage germination could have been secured had the seeds, not germinating at that time, been tried again later on. The seedlings that did start, were vigorous.

WILD BUCKWHEAT: Seeds all decayed. The outer seed envelope (wall of the ovary) was present, and not much decayed. Means of decay, such as fungi and bacteria, seem to have gained access along the angles of the seed.

WILD OATS: Seeds all decayed, almost beyond recognition. The result of this experiment in regard to the wild oats is contrary to the received opinion. The water may have had an adverse effect, though it is doubtful. This part of the experiment is being repeated.

NOTES ON FRENCHWEED (*Thlaspi arvense*).

SUMMARY.

1. Frenchweed seed remaining in pods out of doors over winter is usually dead by spring.
2. A Frenchweed plant with green pods, plowed under, will ripen its seeds much quicker than when left above ground.
3. Frenchweed will ripen pods in seventy-seven days from sowing and in thirty-four from the flower.
4. After the pod is ripe it requires nearly a year to mature seed, if it be stored dry.
5. Frenchweed is most injurious when it starts in the fall. A

well cleaned seed bed in the spring is the greatest foe to the Frenchweed and other winter annuals.

DESCRIPTION: Frenchweed is a plant introduced from Europe which has become a bad weed in eastern North Dakota. It is recognized by its flat orbicular pods, the size of a penny, and is often called pennycress. It is an annual, but generally starts in the fall, lives over winter and ripens its pods in June. This is the winter annual form. The summer form starts in the spring and ripens its pods in July and August.

SEEDS IN WINTERED PODS: When Frenchweed ripens its seeds in the late fall, as it does occasionally, cold weather generally catches the plant before all of the seeds are ripe or distributed. In the spring the plant appears to have mature pods which contain seed. Germination tests were made of such seed in the spring to determine if any were viable. A total of twenty pods were examined, care being taken to select the largest and most mature looking. One hundred and sixty-three seeds were examined, seventy of which were light colored and shrunken, thirty-four appeared of medium quality, and forty-nine of fairly good quality. From this number there were but four germinations, three of which came from the light and shrunken seed and one from the medium quality. Two of the seedlings were very weak.

GERMINATION OF THE GREEN SEED: It is stated by farmers that Frenchweed plowed under, with developing pods, will keep on developing the seed in the pods, practically the same as if the plant had been left untouched. A plant was selected July 18 that had ceased blossoming but that had developed no ripe pods. The oldest were beginning to turn from green to yellow. This was buried in the ground at a depth of four inches. On Sept. 19, the plant was dug up and found quite badly rotted. A large number of the seeds were germinating including some from pods that were quite green. Other seeds, not yet started, were tested in the laboratory, and germinated freely. It is quite crtain that these seeds would not have grown so soon if the plant had been dried, instead of buried in the ground. Four pods were selected and labeled "green," "yellowish," "nearly ripe," and "ripe," and used as control. None of the seeds from these pods grew though kept in the germinator for three weeks. It is apparent that Frenchweed plowed under when the pods have attained their size (not maturity) will develop viable seeds, sooner, at least, than if the plants had remained above ground. However, all the pods buried deep r than two inches are safely taken care of as indicated in the first experiment in this bulletin.

DISTRIBUTION OF SEED: It is often claimed that the wind aids in the distribution of Frenchweed seed by blowing the pods hither and thither. Observation disproves this. When the pod ripens, the two boat-shaped valves fall, leaving the seeds attached to the septum. If the seed falls with the valves it is accidental, and not a part of the distributing mechanism. The broad pods are of use in functioning as leaves.

POD GROWTH: Studies were made upon the rapidity of growth of the Frenchweed pod and upon the time required to mature the same. Measurements were taken in millimeters (mm). Twenty-five mm. equal one inch.

On June 30, a flower in blossom was selected. July 2, petals still on, pod measured 2x2½ mm. (thickness not measured); July 4, petals off, pod measured 4x5 mm.; July 5, pod 5x6 mm.; July 6, pod 5½x7½mm.; July 7, pod 7½x9 mm.; July 8, pod 8½ x10½ mm. July 10, pod 11x13 mm. It retained this size until ripe, Aug. 3. Similar measurements were made upon several other pods and the rate of growth was nearly the same. The pods gain about a millimeter a day in length and in breadth, until normal size is attained, and then the energy of the plant is turned to the formation of seed. It thus happens that the plant has the use of the leaf-like pod for the longest practicable time. The bed containing the plant from which the above measurements were taken was seeded May 2, and first seed ripe July 18, seventy-seven days from sowing.

GENERATIONS PER YEAR: Tests were made to ascertain if two crops of Frenchweed seed could be produced in one season, starting with one lot of seed or with one plant. Plants were selected early in May which had started the fall before, and transplanted to the Frenchweed bed. These grew rapidly and had ripe pods by June 15. The seed from these plants was sown at that time but no germination resulted until early September. These plants did not flower that season but went into winter condition with only root leaves. From the seed sown early in the season, ripe pods were gathered July 18. The seed from these was sown that date but it did not germinate until early September and went into winter condition like the preceeding. Only one crop of seed produced in 1904.

TIME REQUIRED TO MATURE SEED: In July 1903, a quantity of Frenchweed seed was gathered from very ripe pods, the valves fell at the touch. On April 15, 1904, a germination test was made of this. But 1 per cent grew and the testa (coat) of the one seed was evidently broken. (Wheat under similar conditions germinated 97 per cent). A sowing of the Frenchweed seed was made out doors May 5 and less than 1 per cent germinated while wheat in the same bed germinated nearly 100 per cent. On July 13, 1904, a laboratory test was made of the same Frenchweed seed resulting in a germination of 85 per cent. The seed sown with the wheat May 5 did not germinate until the fall rains, about September 1, which allowed the plants to get into good winter condition. We may assume, I think, that the growing wheat kept the soil too dry for the germination of the Frenchweed, after the seed had matured. As soon as the first heavy rain came, after the wheat had ripened, the seeds germinated. The rainfall of the growing season was about the average, being somewhat below the normal in August.

It is evident that there are at least three classes of Frenchweed seed that we have dealt with: (1) Seed gathered with grain in harvest time, stored dry, and sown with the grain the following spring; (2) seed from the winter annual plants which falls to the ground in June; (3) seed from the spring plants which falls to the ground in July. In these three cases ,the seed did not germinate until September, in time to put the plant in good condition as a winter annual.

CONCLUSION: The conclusion from this seems to be that the *Frenchweed is a pernicious plant only as a winter annual.* If the seed bed of the grain field is harrowed clean before seeding, or if the land is spring plowed, Frenchweed will be uncommon in the grain. This conclusion is substantiated by the few field observations made by the author. A very wet season might change the results somewhat and some exceptional seeds may germinate soon after the pod is ripe.

Observations upon two other winter annuals, Peppergrass (*Lepidium apetalum*), and Tumbling Mustard (*Sisymbrium altissimum*), confirm the general conclusion. Peppergrass was seeded May 2. The following is taken from my notes. May 16—"Coming nicely, seed leaves open." May 18—"Seedlings making slow progress." July 1—"Seedlings nearly dead." July 29—'Some of the seedlings beginning to come on." August 16—"Seedlings just living." In the same bed were three plants of the winter annual form which throve vigorously. The seed of the plants with retarded growth was of excellent quality. It is remarkable why the seeding of May 2 acted as it did. It is possible that cool (fall) weather is necessary for the early growth of the plant. If further work confirms the above it is certain that Peppergrass is a pernicious weed, only as a winter annual.

Tumbling Mustard, seeded May 3, made an excellent growth but somehow it forgot to blossom. On July 1 plants were six inches high but stemless. On July 15, two plants had sent up flowering stalks and were beginning to blossom. Aug. 2—"Flower stalks becoming abundant. Will not produce much seed this year." No ripe seed was produced until the middle of October and it did not start seedlings that season. Some of the plants that germinated in May did not send up flowering stalks that season.

Tumbling Mustard, seeded with other plants in the spring, showed itself very weak as indicated in the following experiment. It is very certain that *this plant is a pernicious weed, only as a winter annual.*

RELATIVE AGGRESSIVENESS OF DIFFERENT WEEDS.

Eight hundred seeds each, of six different kinds of weeds, were counted out and sowed May 10, 1904, in a bed 5x7 feet. The kinds of weeds were: Russian Pigweed (*Axyris amaranthoides*), Tumbling Mustard, Wild Mustard (*Brassica arvensis*), Frenchweed, False Flax, (*Camelina sativa*), and Ball Mustard (*Neslia paniculata*). The percentage germination of the above seeds was good except Frenchweed, the seed of which had not yet 'matured." The seed had been gathered the previous year in excellent condition, was well dried and had been stored carefully. Seedlings began to appear May 16. On July 1, Wild Mustard showed most abundant leaf surface and False Flax next. On July 19, when the plants had evidently attained their maximum size, they were pulled, counted, and the relative sizes of the piles estimated. The number of plants of each kind were: False Flax 520; Wild Mustard 356; Russian Pigweed 281; Ball Mustard 195; Frenchweed 24; Tumbling Mustard 3. Estimating the Wild Mustard pile—the largest—as 10, False Flax came next as 6, Russian Pigweed 1 (plants small), Frenchweed .5, Ball Mustard .5 and Tumbling Mustard .05. This emphasizes the weakness of Tumbling Mustard especially when it has to cope with really aggressive plants and it shows how little it need be feared when it is placed in competition with a rapidly growing plant, even like the wheat plant. When Tumbling Mustard injures a grain crop it is because the grain is sown in a field full of Tumbling Mustard plants already half grown.* Russian Pigweed and Ball Mustard also show a decided weakness when thep cope with their superiors.

Quack Grass: The eastern Quack grass or Couch grass is invading the state in many places and attention is called to the matter. Two cuts from photographs of the plant are given, showing the mass of rootstocks which it produces. It is these rootstocks which make it a pest. All dirt and foreign material have been removed and roots and rootstocks alone are present. When this grass once becomes established, it is easily seen that ordinary methods of cultivation will avail but little. The grass should be attacked in a dry season. The ground should be mowed if the grass is of much height, and so plowed that the bottom of the furrow is level with the bottom of the mass of roostocks, shown in the cut. Cultivation should be thorough and should be done with a

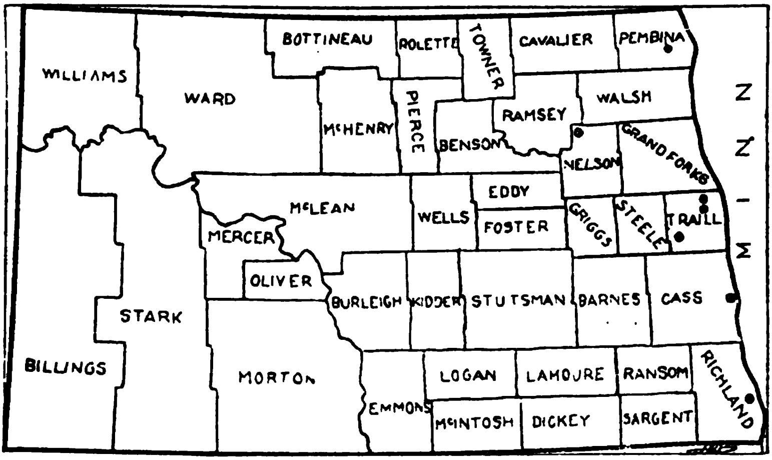

FIG. I.—Map showing distribution of Quack Grass in North Dakota as known at present. It probably occurs elsewhere in the state

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*The Tumbling Mustard seed was the same used to seed the bed of that plant in the weed garden, and when alone made a vigorous growth.

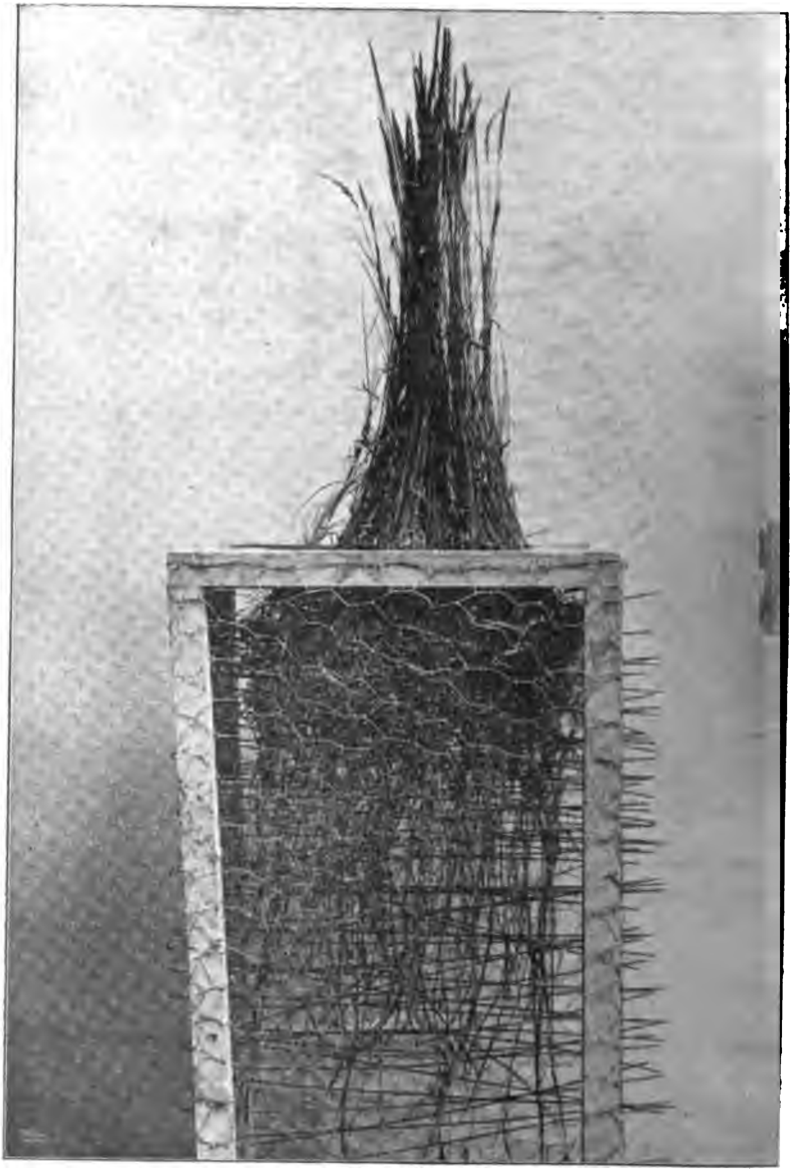

FIG. II.—Showing roots and rootstocks of QUACK GRASS. All dirt and foreign material have been removed

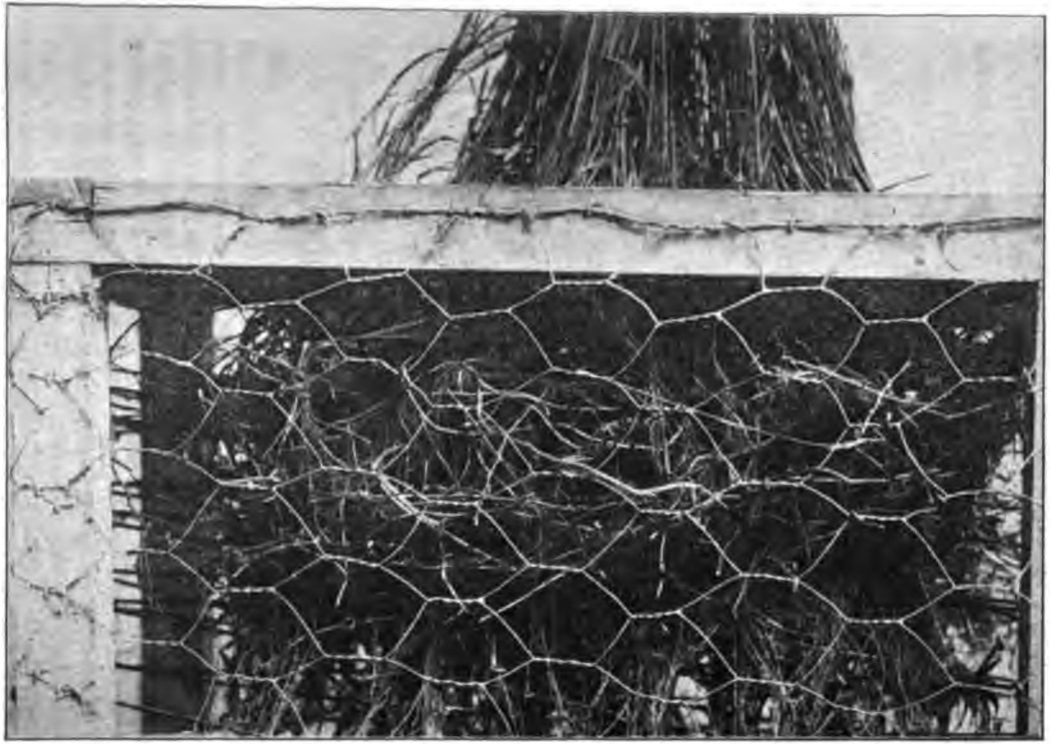

FIG. III.—Showing a portion of Fig. II at closer view. The individual rootstocks of the Quack Grass can be easily seen. (Thanks are due to Mr. Oliver Dynes, a student, for his efficient aid in the preparation of this sample)

tool that cuts off the stems just below the surface. After the grass is weakened by this method, the ground should be thickly seeded with a quick growing grass in order to smother the Quack.

A square foot of Quack grass sod was selected and excavated to the depth of the rootstocks, about five inches. The soil was carefully washed away from the rootstocks and their length measured. This proved to be a total of eighty-six feet. The culms or stalks with heads, arising from that area, numbered ninety. As each rootstock has a joint on an average every two inches and is capable of sending up a stalk at that place, it follows that the rootstocks in a square foot of sod have the ability (potentially) of producing over 500 plants. This shows how harrowing may tend to distribute, rather than check, the growth of the plant.

Growth of Rootstocks: Fresh rootstocks of Quack were cut into lengths of one, two, three, four and six inches respectively and placed in the germinator to determine ability to grow. Six of the one inch, and four of the two inch lengths, had no joints and no growth resulted.

Rootstocks 1 inch long—number, 16, number grew, 6.
Rootstocks 2 inches long—number, 26, number grew, 19.
Rootstocks 3 inches long—number, 13, number grew, 12.
Rootstocks, 4 inches long—number, 13, all grew.
Rootstocks 6 inches long—number, 8, all grew.

CANADA THISTLE AND SOW THISTLE.

These two plants are continually invading new territory, and they will soon demand more attention than they are receiving now. Canada Thistle invaded the state along the northern boundary of Pembina and Cavalier Counties. At present it is quite abundant in those two counties, especially the former. In Pembina County it is not uncommon to see an area of twenty-five or thirty acres occupied by this pest, while smaller patches are relatively more common. The methods of farming in vogue there, seem to check the growth of the plants only slightly. Continued wheat crops afford excellent opportunities for growth of these plants. Canada Thistle plants do not become thick enough on the ground to prevent the development of a certain amount of wheat. Such wheat certainly does not yield more than half a crop, an amount too small to pay running expenses. Those areas infested with Canada Thistle become dead property, as far as small grain growing is concerned. As the infested areas become larger, the value of the land in such communities and counties correspondingly diminishes. The accompanying map shows the distribution of Canada Thistle as known by us at present. The map shows the locations from which plants have been received or collected. It undoubtedly occurs elsewhere in the state.

The Sow Thistle may be recognized by its slightly prickly leaves, milky juice and bright orange flowers. The seeds (fruits) have white hair-like bristles attached to them. The plant is ordinarily three to four feet tall. It spreads by means of underground stems or rootstocks, commonly spoken of as "roots." At intervals of a few inches these send up branches which develop into green plants. These may develop flowering stalks, or the plant may remain stemless, having only a few root leaves. In a field that was quite weedy and evidently much cropped it was evident that the Sow Thistle had drawn largely on the available plant food. In a patch four or five rods in diameter, the flowering stalks numbered only eight to ten to the square rod, while the stemless plants formed a virtual mat upon the ground, numbering thirty to forty to the square foot. A strip on the edge of the patch of

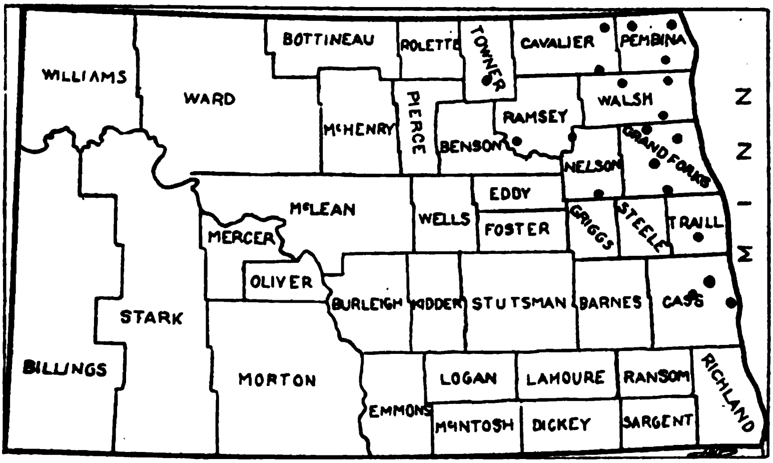

FIG. IV.—Map showing distribution of CANADA THISTLE in North Dakota as known at present. It probably occurs elsewhere in the state

one or two feet in width consisted of Sow Thistles that were invading new ground which was probably more fertile. In this strip the flowering stalks were somewhat larger and numbered six to eight to the square foot. Wheat was sown on this ground in the spring, but at this time was scarcely in evidence. There were sixteen to twenty-four wheat culms or stalks to the square foot where there should have been 200 or more. The stalks stood from six to nine inches in height and each bore from three to five spikelets. The yield from such an area would approximate four pounds per acre, or about one four-hundredth of the normal crop. A few vetches and roses were found in the patch but these were insignificant in both number and size. In one or two places where animal droppings were present the Sow Thistles were thicker and more robust and the wheat stalks were as tall as the thistles, with moderated sized heads. Scarcely any seed was produced by the thistle flowers in the patch described. In other patches about five to ten per cent of the flowers produced seed.

From the different effects of Canada Thistle and Sow Thistle upon the wheat sown with the weeds, it is evident that the Sow Thistle has a stronger hold upon the land than the Canada Thistle. In certain places in the field Canada Thistle and Sow Thistle patches were disputing each other's territory. In such cases it was evident that the Sow Thistle had the better fighting qualities, for it was rapidly invading the Canada Thistle area, while the Canada Thistles produced few plants within the Sow Thistle area.

No work has been done by the station upon eradication of the Sow Thistle. It is certain that little can be done, in the regions where they are most prevalent, until the methods of farming are changed materially. Intensive methods must supplant the extensive methods, so commonly in use. Summer fallow or cultivated crops must alternate with grain crops. In addition a certain amount of hand work must be done. A farmer should be content with nothing less than eradication of such weeds. The apparent apathy with which some farmers regard such a pest as the Sow Thistle is difficult to conceive. It would be a simple thing to cut the flowering plants, thus preventing new areas from becoming infested by the wind-carried seeds. but apparently very little of this is done. A man has no moral right to allow his own farm to become infested by the plant and it becomes criminal negligence when his neighbor's lands become involved through his carelessness. A common sense weed law should be drafted and passed. This should embody the appointment of a weed inspector whose duty it would be to enforce the law in needed cases.

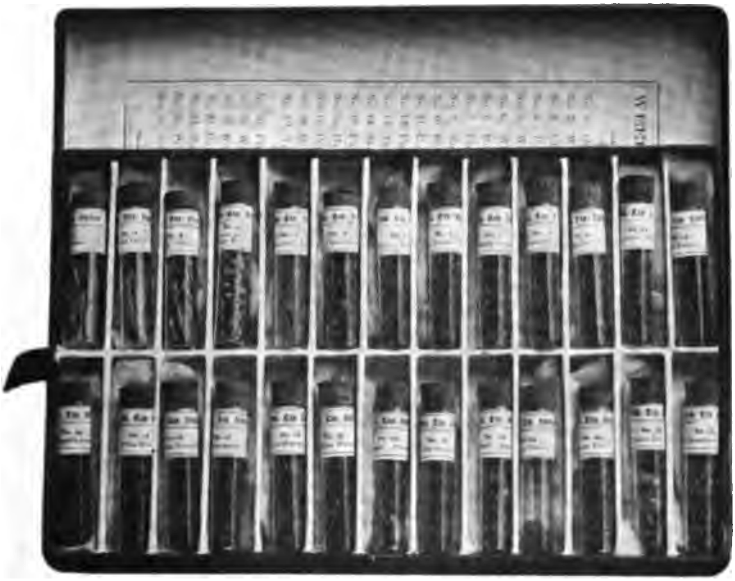

FIG. V.—Showing collection of noxious weed seed prepared by the Botanical Department, North Dakota Experiment Station, for distribution among farmers and seedsmen. For particulars write to C. E. Nugent, Sec., Agricultural College, N. Dak.

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NORTH DAKOTA.

Bulletin No. 63.

ADULTERATED FOOD PRODUCTS AND FOOD STUDIES.

By E. F. LADD,
Chemist and Food Commissioner.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
November, 1904.

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ADULTERATED FOOD PRODUCTS

BY E. F. LADD, CHEMIST AND FOOD COMMISSIONER.

The analytical data for this bulletin was furnished jointly by the author, C. D. Holley, C. H. Kimberly, J. H. Norton and A. G. Nickle.

The mass of data accumulated under the working of the state food law has reached such proportions that it is impossible to present the entire list of products examined during the year. In this bulletin we have decided to present just the list of products found to be adulterated and to discuss these more fully and reserve the legal products as a part of our forthcoming report now in course of preparation.

The method laid down at the time when the law went into effect, namely to depend more largely upon personal work with the manufacturers and jobbers to induce them to have their products in compliance with the requirements of our law has been followed out with good success. Our method has been therefore:

1. To induce manufacturers and jobbers to have goods in compliance with the law.
2. To give wide publicity to all food frauds.
3. To induce retailers to leave illegal goods alone.
4. To induce the public to demand pure food products and beverages.

The first question to be answered then, is what are the requirements of the North Dakota Food Law. I believe the following answers this question:

1st. Harmful and unnecessary preservatives are prohibited from being used in food products.

2nd. The use of Coal Tar dyes is prohibited in all food products and beverages offered for sale in North Dakota.

3rd. That all food products must be labeled true to name and no deception practiced in the wording of the label so as to mislead the purchaser or consumer.

These three cardinal principles have been kept in mind in all our food work. It can not be said that this is an unnaatural law, or that its enforcement should work any great hardship on the honest manufacturers. In fact the manufacturers of high grade pure goods have not complained, but the man who produces inferior products made to appear as of high grade by the use of chemicals, or the man who poses as a friend of pure foods, but whose goods are not what the public suppose them to be, is the man who has opposed the law. For example one large concern admitted that if saccharin was to be condemned in all classes of products, it meant an expense of $10,000 per year to his houses as against $500 at the present time. Is it not natural that he should be opposed to our food law? And yet these goods have not retailed at a less price than others of better grade put up under more sanitary conditions, and if need be sweetened with cane sugar.

Facts like the above are not stated by the manufacturers as an argument why the public should be served with saccharin instead of sugar as an article of food, but from time to time these facts are admitted. Men who can sell apple jelly and glucose for currant, strawberry, etc., make a large profit and naturally are opposed to honest labeling.

It is believed, however, that in this state, at least, the public are fast coming to demand pure food products, and they are willing to pay for the same.

I might quote from many interesting letters which have come into my possession at one time and another in the enforcement of the food law of the state. I recently saw a letter written on letter headpaper of Curtice Bros. Co., Rochester, New York and signed by Curtice Brothers Co., which letter is not published for the obvious reason it might be unpleasant for the parties to whom the letter was sent. The letter stated, however, that jams and preserves could not and would not be prepared without the use of a preservative. The letter further states that their jams and preserves contained a chemical preservative, the use of which is generally condemned in states having pure food laws, and which by legislative enactment is prohibited in North Dakota. It was further stated that they were willing to send these goods into North Dakota and stand back of them. The same information has reached us repeatedly during the past year through both retail merchants who have handled the goods from this house and from other sources as well.

Such a course as indicated above would seem to clearly indicate that this company does not intend to comply with the law of the state but openly boast of their willingness or intention to violate it. They say that their jams and preserves contain a preservative, and they are perfectly willing to send these goods into North Dakota and stand back of them. If they are willing to openly defy and violate the law in this respect, do the public want to use their jams and preserves? I mention this case as one of the most open thrusts by a large firm which might have been expected to stand ready to comply with the law.

I can not accept, however, their assertion that all firms who put up this class of goods use preservatives. My records do not show this to be the fact for the past year at least. There were plenty of this same class of products found in North Dakota which did not contain benzoate of soda or any other chemical preservatives. Again, the use of a preservative in these products seems to meet a commercial convenience rather than being necessary as a food preservative where the fruits are prepared as preserves, jams and etc. while fresh.

This firm is advertised as one of the twenty-eight firms affiliated under the name of "The Association*
of Manufacturers and Distributers of Food Products" which association according to the "Grocery World" is opposed to existing and proposed food legislation, for it says: "The Association of Manufacturers and Distributors of Food Products disproves of certain parts of the bill regarding preservatives, and will fight it hard unless these are removed. The association can command some political influence, and if it sets out to oppose this bill the chance of its passage will not be bright."

The manufacturers who comprise the Association of Manufacturers and Distributers of Food Products have at last resolved to make a firm stand on the use of preservatives."

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*A representative of the above named house recently visited my office and assured me that the letter which I saw does not represent the true attitude of Curtice Bros. Co. toward North Dakota and its food law and further that the company has withdrawn from membership in the "Association of Manufacturers and Distributers of Food Products." If this letter did not represent the true sentiment then why was it written and why have not the dealers been differently informed during the past year?

If Curtice Bros. Co. are willing to meet the requirements of the food law of North Dakota we are glad to have them do business in the state since they are producers of many high grade goods and we much regretted to see them assume a hostile attitude.

In other words then this association proposes to dictate to the American people as to what chemicals they shall eat in their food and to force legislation to their terms or to block all pure food legislations of the country. To this end its members are willing to violate the food laws of the state when the same conflicts with the course which they desire to follow. According to the "Grocery World" of Oct. 31, 1904, this association is engaged in the courts trying to overthrow the wishes of the people of Pennsylvania as expressed in legislative enactment prohibiting the use of chemical preservatives in jellies, preserves, etc.

It will be well to see that interested parties do not succeed in securing such legislation in this state as will permit of the development of food frauds and abuses such as existed before the enactment of our present food law.

PRESERVATIVES AND COLOR IN FOOD PRODUCTS.

The North Dakota Food Law prohibits by statuary enactment the use of certain well known harmful preservatives as well as all coal tar or aniline colors. This provision of the law has been criticised much by manufacturers who are in the habit of using these products in foods and beverages. It has been equally commended by many manufacturers of honest goods. It will be interesting to many to know that at the International Pure Food Congress and the Annual Convention of the State and Dairy and Food Departments held in St. Louis resolutions were adopted condemning the use of these products and directly in harmony with this feature of our state law.

The following is the report of the committee as adopted by the Congress:

ANTISEPTICS AND COLOR.

Whereas, Certain food products have distinct natural colors which are regarded as indices of excellence and purity; therefore, be it resolved by this Congress:

1. That we deprecate the artfical coloring of food products to imitate the natural, distinctive tints referred to above, and urge upon food manufacturers the propriety of discontinuing the use of pigments of any kind for the purpose above mentioned.

2. That the manufacturer of food products which are mixtures or compounds having no distinctive colors and which are used as candies, confections, ices, delicacies and desserts, and which are expected by the consumer to be colored or tinted, only such colors, preferably of vegetable origin, shall be used, which are determined by acknowledged authorities to be harmless; and the use of aniline or other coaltar dyes, mineral colors and synthetic colors of all kinds is regrettable.

Whereas, There are available unobjectionable methods of preserving foods, for example, limited cold storage, dessication, sterlization and the use of the long employed and condimental preserving agents, such as salt, sugar, vinegar and wood smoke; therefore, be it resolved:

1. That this Congress does not approve of the use of preservatives or antiseptics in the preservation of food other than those named.

2. That since a preservative or antispetic other than those above named to be effective must destroy or paralyze all fermentative organisms, they induce a condition which must be more or less unfavorable to digestion, and they are therefore to this extent hurtful.

3. That the use of preservatives and antiseptics other than those above named in minimal quantities is not a justification of their employment, since even in minimal quantities, where their use is long continued, they may become harmful.

4. That the use of preservatives and antiseptics other than those mentioned above must be, previous to their use, justified by the manufacturer, and no citizen should be required to ascertain for himself whether or not the food we consume contains an added preservative other than those mentioned above, and therefore when any other preservative or antiseptic is added to food the name and amount thereof should plainly appear upon the label.

There was also adopted resolutions regarding standard for baking powders and methods of labeling as follows:

BAKING POWDERS.

Resolved, That all baking powders shall be free from deleterious, injurious or unwholsesome substances.

2. That they shall contain no substances which are not necessary thereto as active agents except starch or sugar, which are recognized as essential and necessary.

3. That certain rigorous or fixed standards be recommended which shall determine the minimum amount of carbonic acid gas.

4. That all packages shall bear a correct statement of their composition in plain legible type and language easily understood by the average purchaser and consumer, and also the name and address of the manufacturer or producer.

5. That no package shall bear any statement which will deceive or tend to decive the purchaser.

Clauses four and five are particularly to be commended and should be enforced fully. I am aware that several baking powders now sold in this state are very far from meeting all of the requirements of the last recommendation, in fact, they contain statements so worded as to deceive the purchaser and were probably so intended by the manufacturers, and steps will be taken in the near future to enforce a ruling covering this particular feature on all baking powders to be offered for sale in the state.

ALCOHOLIC MEDICAL BEVERAGES.

North Dakota being a prohibition state many products have been prepared and offered for sale under the guise of being a proprietary medicinal preparation, good for nearly all ills to which man is heir to, but which in reality have a good amount of alcohol as the main ingredient. It is generally recommended that from one wine glass to six be taken per day for the various ailments which nearly all men imagine they may have. During the past year a number of such products have been examined to determine what per cent of alcohol they contained. In certain localities these remedies seem to have become very popular, and are prominently displayed in drug store windows, and their use is said to be largely on the increase.

Below we give a few of those recently examined and a statement of the amount of alcohol contained in each.

1850 Peruvian Tonic "A nerve and system builder and an invaluable tonic for brain and body; made by L. W. Leithead Drug Co., Duluth, Minn.

1851 Leithead's Stomach Bitters, L. W. Leithead Drug Co., Duluth, Minn. 'A highly aromatic liquid and entirely free from any injurious substances."

1887 Old Kentucky Bitters, Rea Bros. & Co., Minneapolis, Louisville and New York. "An ideal tonic and stimulant. A few doses of Old Kentucky Bitters will ward off any bad effects."

2062 Peruna, The Great Tonic, Peruna Medical Co., Columbus, Ohio. After enumerating twenty-one diseases for which Peruna is recommended as a cure it further states "For female complaints, suppressed or painful menstruation, sexual impotency or weakness, it is a reliable panacea.

2407 Improved I. X. L. Bitters, prepared by I. X. L. Chemical Co., Chicago. "The best tonic and appetizer." "These bitters may be sold for medicinal purposes by the bottle without a license.

2431 Richard's LaGrippe Specific, Richard Chemical Co., Minneapolis. An excellent remedy for coughs, colds, lagrippe and all throat and lung affections.

The per cent of alcohol actually found in each of these products is given below:

		Per Cent of Alcohol by Volume
1850	Leithead's Peruvian Tonic	24.94
1851	Leithead's Stomach Bitters	41.80
1887	Old Kentucky Bitters	30.31
2062	Peruna	25.90
2407	I. X. L. Bitters	27.40
2431	Richard's LaGrippe Specific	24.02

That these products have but little to recommend them aside from the alcohol portion is shown from the fact that Leithead's Stomach Bitters with 41.80 per cent of alcohol contains but 1.26 per cent of total solids and a mere trace of ash or 0.001 gram in twelve grams of the substance. Of the total solids nearly 1.20 per cent was sugar.

In the Old Kentucky Bitters the solids amounted to 6.697 per cent, with 0.0018 per cent ash. The solids were mainly sugar.

Peruna contained but 0.37 per cent of total solids and an unweighable amount of ash.

Richard's LaGrippe Specific, was found to contain 8.20 per cent of total solids, a very sweet and syrup like product with no pungent or bitter taste of any other product than sugar and possibly caramel for color. The total ash was only .0042 per cent, or 0.4 milligrams in ten cubic centimaters of liquid. In fact the only product found other than alcohol solution was sugar and a slight amount of coloring matter, probably caramel.

LIQUOZONE.

This product is largely advertised and sold in North Dakota, and has frequently found its way to our laboratory for analysis. It is made by the Liquid Ozone Company, Chicago. After enumerating fifty diseases for which liquozone is recommended they add "All diseases that begin with fever—all inflammation, all catarrh in any part of the body, all contagious diseases, all the results of impure or poisoned blood." "We will pay $1,000 to the physician or scientist who discovers a disease germ which liquozone cannot kill." "Liquozone, liquid oxygen invariably cures any trouble caused in any way by germs." It will be seen by the last statement an attempt is made to convey the idea that liquozone is liquid oxygen, a ridiculous and false statement. They would have the public believe liquozone a cure all for everything, from weak eyes to asthma, pneumonia and piles. In water it will purify it, and prevent typhoid. In milk it will sterilize it, and in beer it prevents fermentation and biliousness.

What is this wonderful product so persistently advertised and lauded by its interested promoters? One sample of liquozone was found to contain a total acidity of 1.34 per cent of which 1.18 per cent was in the form of sulfuric and sulfurous acid. The total solids a black liquid residue of acid reaction amounted to 1.82 per cent, and the ash residue to 0.025 per cent. The character of the solid and ash clearly indicated free acid. Other samples examined by us have shown an acid content of as high as 1.73 per cent indicating that the product is not by any means uniform in its composition. The free use of any product containing this amount of uncombined sulfuric and sulfurous acid can not be looked upon as wholly without possible harmful effect upon the human system. The public will do well to use such products only upon the advise of the family physician.

PRESERVES, JELLIES AND JAMS.

It is with this product that the greatest amount of difficulty is experienced. There are found in the state products from every part of the country and it is with difficulty that their introduction is prevented. In fact some grocers are more than indifferent or careless in buying these products, and it may be necessary in the near future to make prosecutions among this class of merchants before they come to realize their responsibility under the food law.

Many of the products on the market one year ago were wholly imitation jellies, preserves, etc., colored with coal tar dye, sweetened with glucose and saccharin containing chemical preservatives. The basis for the better class is usually apple jelly, while the cheaper products contain a good quantity of starch and the whole is falsely labeled as strawberry, currant, etc.

In this list we have included a number of products which were examined by request of the manufacturers or jobbers before offering the same for sale in the state. For that reason the showing is made to appear worse than the facts would warrant. In this way a number of products have been examined for the E. S. Burnham Co. of New York, and they repeatedly changed their formulas until products were had which complied with the law. The same may be said of the Erie Preserving Co's. goods and it is believed that these and other large houses have tried to follow out the spirit of the law and gradually this class of products is improved. Lack of funds has prevented systematic work. It is to be hoped, however, that more attention may be devoted to the work during the coming year, and it is believed that the coming year will see a marked improvement in this class of goods.

Manufacturers have claimed that preserves, etc., put up with pure granulated sugar tends to crystalize badly and for that reason we have not classed, as illegal, products containing glucose, not to exceed 10 per cent of the total sugar used. All other products containing glucose in greater amounts are considered as illegal, as are also goods when it is claimed that they are put up with granulated sugar.,

PRESERVES, JELLIES AND JAMS, ILLEGAL.

Lab. No. 1254.
Brand, Marmalade, Orange.
Producer or Jobber, Wm. P. Hartley, Liverpool.
Retailer, Fargo Grocery Co., Fargo, N. D.
Contains salicylic acid.

Lab. No. 1280.
Brand, Strawberry Preserves, Monarch.
Producer or jobber, Reid, Murdoch & Co., Chicago.
Retailer, Fargo Grocery House, Fargo, N. D.
Contains salicylic acid, colored with coal tar dye.

Lab. No. 1282.
Brand, Jellycon Raspberry, Burnham's.
Producer or Jobber, E. C. Burnham Co., New York, N. Y.
Retailer, Baldwin & Thompson, 1st Ave. So., Fargo, N. D.
Contains coal tar dye.

Lab. No. 1289.
Brand, Preserved Strawberries, Shield.
Producer or Jobber, . S. Farren & Co., Batimore, Md.
Retailer, Lewis, Vidger, Loomis Co., Fargo, N. D.
Sweetened with saccharin.

Lab. No. 1292.
Brand, Strawberries, Shield
Producer or Jobber, J. S. Farren & Co., Baltimore, Md.
Retailer, Lewis, Vidger, Loomis Co., Fargo, N. D.
Contains salicylic acid.

Lab. No. 1312.
Brand, Preserved Red Raspberries, Shield.
Producer or Jobber, J. S. Farren & Co., Baltimore, Md.
Retailer, Lewis, Vidger, Loomis Co., Fargo, N. D.
Contains saccharin.

Lab. No. 1316.
Brand, Strawberries, Monarch.
Producer and Jobber, Reid, Murdoch & Co., Chicago.
Retailer, Fargo Grocery Co., Fargo, N. D.
Contains coal tar dye.

Lab. No. 1317.
Brand, Pineapple, Monarch.

Producer and Jobber, Reid, Murdoch & Co., Chicago.
Retailer, Fargo Grocery Co., Fargo, N. D.
Large amount of salicylic acid.

Lab. No. 1324.
Brand, Preserved Strawberries, Pride of Rome.
Producer or Jobber, Olney Canning Co., Oneida, N. Y.
Retailer, Fargo Mercantile Co., Fargo, N. D.
Contains coal tar dye.

Lab. No. 1365.
Brand, Red Raspberry Preserves, Home.
Producer or Jobber, Griggs, Cooper & Co., St. Paul, Minn.
Retailer, Thompson Bros., Cooperstown, N. D.
Contains coal tar dye.

Lab. No. 1373.
Brand, Red Currant Fruit Preserves, Monarch.
Producer and Jobber, Reid, Murdoch & Co., Chicago.
Retailer, Fargo Grocery Co., Fargo, N. D.
Colored with coal tar dye.

Lab. No. 1387.
Brand, Strawberries Preserved, Dinner Party.
Producer or Jobber, Orchard Park Canning Co., Orchard Park, N. Y.
Retailer, Benner, Begg & Garvin, Grand Forks, N. D.
Colored with coal tar dye.

Lab. No. 1408.
Brand, Candied Cherries, Neyre's Extra.
Producer or Jobber, R. U. Delephana & Co., N. Y.
Retailer, Fargo Grocery Co., Fargo ,N. D.
Colored with coal tar dye.

Lab. No. 1413. (By Request).
Brand, Red Raspberry Jam, Pure Fruit and Sugar.
Producer or Jobber, Griggs, Cooper & Co., St. Paul, Minn.
From Company.
Not properly labeled as it is not pure Red Raspberry.

Lab. No. 1414. (By Request).
Brand, Strawberry Jam, Pure Fruit and Sugar.
Producer or Jobber, Griggs, Cooper & Co., St. Paul, Minn.
From Company.
Not properly labeled. Is not pure strawberry.

Lab. No. 1418. (By Request).
Brand, Standard Blueberries, Gopher.
Producers or Jobbers, Foley Bros. & Kelly, St. Paul, Minn.
From Company.
Badly spoiled before being canned.

Lab. No. 1430.
Brand, Black Currant Jelly, Home.
Producer or Jobber, Griggs, Cooper & Co., St. Paul, Minn.
Retailer, J. Markuson & Co., Dazey, N. D.
Contains coal tar dye.

Lab. No. 1462.
Brand, Quince Jam, Pure Fruit Jam.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Retailer, Fargo Grocery Co., Fargo ,N. D.
Colored with coal tar dye.

Lab. No. 1468.
Brand, White Cherries, Bonita.
Producer or Jobber ,Griffith Durney Co., San Francisco, Cal.
Retailer, Fargo Gdocery Co., Fargo, N. D.
Contains borates.

Lab. No. 1524.
Brand, Orange Marmalade.
Producer or Jobber, Wm. P. Hartley, Liverpool.
Retailer, R. U. Delapenha & Co., N. Y.
Contains salicylic acid in large amount.

Lab. No. 1546.
Brand, Preserved Strawberries, Honey Dew.
Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, Rathman Bros., Jamestown, N. D.
Colored with coal tar dye.

Lab. No. 1547.
Brand, Preserved pitted Red Cherries, Honey Dew.
Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, Rathman Bros., Jamestown, N. D.
Colored with coal tar dye.

Lab. No. 1586. (By request.)
Brand, Rasberry Preserves, Belmont.
Producer or Jobber, Chicago Concentrating Co., Chicago.

From Co.
Not pure raspberry, but has apple or other fruit.

Lab. No. 1587.
Brand, Strawberry Preserves, Puritan.
Producer or Jobber, Manierre-yoe Syrup Co., Chicago.
Retailer, Winston, Harper Fisher & Co., Minneapolis.
Contains saccharin, sulphites and coal tar dye.

Lab. No. 1588.
Brand, Red Rasberry Preserves, Puritan.
Poducer or Jobber, Manierre-yoe Syrup Co., Chicago.
Retailer, Winston, Harper, Fisher & Co., Minneapolis, Minn.
Contains sulphites and saccharin.

Lab. No. 1589. (By request.)
Brand, Preserved Strawberries.
Produser or Jobber, Bishop & Co., Los Angeles, Cal.
From Company.
Colored with coal tar dye.

Lab. No. 1593. (By request.)
Brand, Logan Berries.
Producer or Jobber, Bishop & Co., Los Angeles, Cal.
From Co.
Colored with coal tar dye.

Lab. No. 1633. (By request.)
Brand, Jelly Con. Burnham's.
Producer or Jobber, E. S. Burnham Co., New York.
From Company.
Colored with coal tar dye.

Lab. No. 1634. (By request.)
Brand, Jelly Con. Burnham's.
Producer or Jobber, E. S. Burnham & Co., New York.
From Company.
Colored with coal tar dye.

Lab. No. 1705.
Brand, Quince Preserves, Monarch.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Colored with coal tar dye.

Lab. 1706.
Brand, Red Current Preserves, Monarch.

Producer or Jobber, Reid Murdoch & Co., Chicago.
Colored with coal tar dye. Not pure currant jelly.

Lab. No. 1707.
Brand, Strawberries, Preserves, Monarch.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Colored with coal tar dye.

Lab. No. 1708.
Pineapple preserves, Monarch.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Contains large amount of salicylic acid.

Lab. No. 1721. (By request.)
Brand, Crushed Strawberries.
Producer or Jobber, Manierre-yoe Syrup Co., Chicago.
Retailer, C. A. Everhart & Co., Fargo.
Colored with coal tar dye.

Lab. No. 1726.
Brand, Red Cherries Preserved, Honey Dew.
Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, G. L. Farnham, Carrington, N. D.
Colored with coal tar dye.

Lab. No. 1727.
Brand, Strawberries, Preserves, Honey Dew.
Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, G. L. Farnham, Carrington, N. D.
Colored with coal tar dye.

Lab. No. 1754.
Brand, Crushed Cherries.
Producer or Jobber, Manierre-yoe Syrup Co., Chicago.
Retailer, C. A. Everhart & Co., Fargo, N. D.
Colored with coal tar color.

Lab. No. 1763. (By request.)
Brand, Jellycon, Raspberry.
Producer or Jobber, E. S. Burnham Co., New York.
A small amount of coal tar dye.

Lab. No. 1833.
Brand, Marschino Cherries, Victor.
Producer or Jobber, Rheinstrom Bros., Cincinnati, O.
Retailer, W. B. Howland, Fargo, N. D.
Colored with coal tar dye.

Lab. No. 1834.
Strawberries, Jelly, Club House Brand.
Producer or Jobber, Franklin MacVeagh & Co., Chicago.
Retailer, W. B. Howland, Fargo, N. D.
Colored with coal tar color.

Lab. No. 1845.
Brand, Purity. Raspberries Preserves.
Producer or Jobber, F. G. Dailey Co., Detroit, Mich.
Retailer, T. E. Yerxa, Fargo, N. D.
Contains sulphites and coal tar color.

Lab. No. 1860.
Brand, Maraschino Cherries, Monarch.
Producer and Jobber, Reid Murdoch & Co., Chicago.
Retailer, T. E. Yerxa, Fargo, N. D.
Colored with coal tar dye.

Lab. No. 1866.
Brand, Strawberry Jelly, Belmont.
Producer or Jobber, Chicago Concentrating Co., Chicago.
Not a pure strawberry jelly, mainly apple jelly.

Lab. No. 1883.
Brand, Strawberry Jam, Pure Fruit.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Retailer, Mickelson Mercantile Co., Bismarck, N. D.
Not a pure strawberry jam. Not properly labeled.

Lab. No. 1836.
Brand, Red Cherries, Honey Dew.
Producers or Jobbers, Erie Preserving Co., Buffalo, N. Y.
Retailer, John Yergen, Bismarck, N. D.
Colored with coal tar dye.

Lab. No. 1897.
Brand, Preserved Strawberries, Honey Dew.
Producer or Jobber, Erie Preserving Co., Buffalo.
Retailer, T. F. Woods, Bottineau, N. D.
Colored with coal tar dye.

Lab. No. 1899.
Brand, Preserved Pitted Red Cherries, Holiday.
Porducer or Jobber, Madison County Canning Co., Oneida, N. Y.
Retailer, E. Turner, Bottineau, N. D.

Colored with coal tar dye.

Lab. No. 1903.
Brand, Orange Marmalade.
Producer or Jobber, Wm. P. Hartley, Liverpool, England.
Retailer, E. Turner, Bottineau, N. D.
Contains salicylic acid.

Lab. No. 1905.

Brand, Strawberry Preserves, Long.
Producer or Jobber, Long Syrup Refining Co., San Francisco, Cal.
Retailer, E. Turner, Bottineau, N. D.
Colored with coal tar dye.

Lab. No. 1935.
Brand, Strawberries, Old Manse.
Producer or Jobber, Manierro-yeo Syrup Co., Chicago.
Retailer, P. A. Moir, Dickson, N. D.
Contains salicylic acid, coal tar dye.

Lab. No. 1936.
Brand, Strawberry Jam, Honey Dew.
Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, P. A. Moir, Dickson, N. D.
Colored with coal tar dye and largely apple.

Lab. No. 1941.
Brand, Strawberry Preserves, Old Manse.
Producer or Jobber, Manierre-yoe Syrup Co., Chicago.
Retailer, M. Lang Grocery Co., Mandan, N. D.
Contains salicylic acid and coal tar dye.

Lab. No. 1957.
Brand, Preserved Strawberries, Nectar.
Producer or Jobber, Greater New York Canning Co., Rome, N. Y.
Retailer, John O'Rourke Co., Mandan.
Colored with coal tar color.

Lab. No. 1999.
Brand, Strawberries Preserved, Honey Dew.
Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, F. S. Cheney, Pembina, N. D.
Colored with coal tar dye.

Lab. No. 2005.
Brand Currant Jelly.
Producer or Jobber, Berry-Maybrun Co., Chicago, Ill.
Retailer, F. S. Cheney, Pembina, N. D.
Contains sulphites, coal tar dye and not current jelly.

Lab. No. 2017.
Brand, Damson Jam.
Producer or Jobber, Curtice Bros., Rochester, N. Y.
Retailer, Haslam Rodenbud & Co., Devils Lake, N. D.
Contains sulphites.

Lab. No. 2096.
Brand, Pitted Red Cherries, Preserved—Simon Pure.
Producer or Jobber, Lewiston Canning Co., Lewiston, N. Y.
Retailer, J. M. Yoder, Fargo, N. D.
Contains coal tar dye.

Lab. No. 2107.
Brand, Strawberries Preserved, Reception.
Producer or Jobber, Model City Preserving Co., Model City, N. Y.
Retailer, J. M. Yoder, Fargo, N. D.
Colored with coal tar dye.

Lab. No. 2116.
Brand, Strawberries, Popular.
Producer or Jobber, Wm. Fait Co., Baltimore, Md.
Retailer, Great Northern Cash Store, Minot, N. D.
Contains salicylic acid.

Lab. No. 2119.
Brand, Strawberry Jam, Pure Fruit.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Retailer, P. P. Lee, Minot, N. D.
Contains coal tar dye.

Lab. No. 2126. (By request.)
Brand, Red Raspberries. Simon Pure.
Producer or Jobber, Lewiston Canning Co., Lewiston, N. Y.
Retailer, J. M. Yoder, Fargo, N. D.
Coal tar dye present.

Lab. No. 2129.
Brand, Preserved Strawberries, Simon Pure.
Producer or Jobber, Lewiston Canning Co., Lewiston, N. Y.

Retailer, J. M. Yoder, Fargo, N. D.
Colored with coal tar dye.

Lab. No. 2199.
Brand, Currant Jelly, Club House.
Producer or Jobber, Franklin MacVeagh & Co., Chicago.
Retailer, P. J. Bergquist, Fargo, N. D.
Coal tar dye present.

Lab. No. 2209.
Brand, Preserved Strawberry, Princess.
Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, Star Grocery, Fargo, N. D.
Contains coal tar dye.

Lab. No. 2255.
Brand, Strawberries, Wm. P. Hartley's.
Made at Liverpool.
Retailer, Colton Bros., Grand Forks, N. D.
Contains salicylic acid.

Lab. No. 2267.
Brand, Currant Jelly, Home Comfort.
Producer or Jobber, Brant Canning Co., Brant, N. Y.
Retailer, Geo. H. Wilder, Grand Forks, N. D.
Contains sulphites and coal tar dye.

Lab. No. 2272.
Brand, Currant Jelly, Kenwood.
Producer or Jobber, Kenwood Preserving Co., Chicago.
Retailer, M. W. Hansen & Co., Grand Forks, N. D.
Contains sulphites and not currant jelly.

Lab. No. 2301. (By request.)
Brand, Pitted Red Cherries, Home Comfort.
Producer or Jobber, Erie, Preserving Co., Buffalo, N. Y.
Colored with coal tar dye.

Lab. No. 2344.
Brand, Strawberry Jam, Crown Prince.
Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, Park, Grant & Morris, Fargo, N. D.
Colored with coal tar dye.

Lab. No. 2345.
Brand, Red Rasberry Jam, Princess.

Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, Park, Grant & Morris, Fargo, N. D.
Not pure raspberry but contains considerable apple jelly.

Lab. No. 2356.
Brand, Red Cherries, Monarch.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Retailer, W. E. Daniels, Valley City, N. D.
Colored with coal tar dye.

Lab. No. 2358.
Brand, Preserved Strawberries, Monarch.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Retailer, W. E. Daniels, Valley City, N. D.
Contains salicylic acid and coal tar dye.

Lab. No. 2362.
Brand, Red Raspberry Jam, Monarch.
Producer or Jobber, Reid, Murdoch & Co., Chicago.
Retailer, Coop Bros., Valley City, N. D.
Colored with coal tar color and contains filler.

Lab. No. 2363.
Brand, Strawberry Jam, Monarch.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Retailer, Coop Bros., Valley City, N. D.
Contains coal tar dye and not pure strawberry.

Lab. No. 2414.
Brand, Raspberry Preserves.
Producer or Jobber, Minnesota Preserving Co., St. Paul, Minn.
Retailer, O. H. Johnson, Hamilton, N. D.
Contains sulphites, salicylic acid and foreign color.

Lab. No. 2426.
Brand, Apple Butter, Home Made.
Producer or Jobber, Williams Bros. Co., Detroit, Mich.
Retailer, Park, Grant & Morris, Fargo, N. D.
Gives reactions for preservatives of mixed character.

Lab. No. 2427.
Brand, Apple Butter, Dragon.
Producers or Jobber, Williams Bros. Co., Detroit, Mich.
Retailer, Park, Grant & Morris, Fargo, N. D.
Contains salicylic acid.

Lab. No. 2430. (By request.)
Brand, Strawberry Jam.
Porducer or Jobber, Erie Preserving Co., Buffalo, N. Y.
From Company.
Contains salicylic acid.

Lab. No. 2516.
Brand, Imitation Fruit Jelly.
Porducers or Jobber, The Towle Preserving Co., St. Paul, Minn.
Retailers, Griggs, Cooper & Co., St. Paul, Minn.
Contains sulphites, starch paste, and coal tar dye.

Lab. No. 2528.
Brand, Marischino Cherries, Victor.
Producers or Jobbers, Rheimstrom Bros., Cincinnati.
Retailer, W. B. Howland, Fargo, N. D.
Colored with coal tar dye.

Lab. No. 2626. (By request.)
Brand, Imitation Fruit Jelly.
Producers or Jobber, The Towle Preserving Co., St. Paul, Minn.
Contains coal tar dye.

Lab. No. 2639.
Brand, Marrischino Cherries, Big arreaux.
Producers or Jobbers, Dupplessis Freres, Bordeaux.
Retailer, T. L. Stanley & Son, Casselton, N. D.
Contains coal tar dye.

Lab. No. 2670.
Brand, Preserved Strawberries for cream.
Producers or Jobbers, Martin Wagner Co., Baltimore, Md.
Retailer, Thomas Regan, Larimore, N. D.
Contains saccharin.

Lab. No. 2664.
Brand, Anderson's Damson Jams.
Producer, Anderson Preserving Co., Camden, N. J.
Retailers, Thos. Regan, Larimore, N. D.
Colored with coal tar dye, and contains other fruit than damsons.

MAPLE SYRUP AND SUGARS.

Probably there has been no product sold where greater deception has been practiced than in the case of maple syrups. I question whether one year ago there was a single commercial maple syrup generally sold in this state made exclusively from the sap of the maple tree. I am aware that some of the *manufacturers* of these goods have questioned this assertion. A study of the statistics of the maple syrup industry as shown by the last census as compared with the amount estimated to have been sold under this name reveals that the production was about 15 per cent of the consumption, it certainly could not have been 25 per cent. Then how are we to account for the existence of this large amount except on the basis of its having been manufactured.

At the present time there is some attempt at labeling so as to conform with the real facts as to the composition of the product. Unfortunately at the present time much of the pure maple syrup, or that claimed as pure, is a very inferior product of rank flavor. This class of products will soon seek its own level and we shall have developed a demand for a pure sap maple syrup of good quality and flavor. Such a product will command a good price from those who desire a high grade product. Not only will this prove a benefit to the consumer but will result in stimulating an American industry much neglected because of the prevailing methods of handling this product; and the fraud practiced in selling it.

I submit the following list of illegal samples examined with the one explanation that some of the brands have by the manufacture been changed while others are persistently wrong. It will require at least another year to adjust things to the new conditions, and secure a general distribution of pure syrup of a grade such as is sought for by those of cultivated taste.

A syrup made from sugar produced in a careless way, evaporated in open iron kettles from sap not cared for nor freed from dirt can *not* have other than a strong unpleasant flavor and such sugars are only fit for making blended products to be sold as table syrups, but not as maple syrups.

MAPLE SYRUPS, SUGAR AND MOLASSAS—ILLEGAL

Lab. No. 1320.
Brand, Maple Sugar Pure.
Producers or Jobbers, Marshalltown Syrup & Candy Co., Marshalltown, Ia.
Retailer, E. A. Perry, Fargo, N. D.
Not properly labeled.
Illegal.

Lab. No. 1488.
Brand, Maple Syrup.
From Hannah, N. D.
Not properly labeled.
Illegal.

Lab. No. 1580.
Brand, Maple Syrup.
Retailer, L. P. Larson, Grafton, N. D.
Not pure maple syrup, mainly cane sugar syrup.
Illegal.

Lab. No. 1607.
Brand, Pure Mapre Sugar.
Producers or Jobbers, Mylas Youngs, Brockton, Canada.
Not properly labeled.
Illegal.

Lab. No. 1659.
Brand, Maple Sugar, Adirondack. Guaranteed Pure.
Producers or Jobbers, Reid Murdock & Co., Chicago.
Retailers, Hicks Grocery Co., Oakes, N. D.
Not properly labeled.
Illegal.

Lab. No. 1664.
Brand, Pure Vermont Maple Sugar.
Producers or Jobbers, T. R. Waterman, Johnson, Vt.
Not properly labeled. Illegal.

Lab. No. 1666.
Brand, Mapel Sugar.
From Ohio.
Not properly labeled.

Lab. No. 1775.
Brand, Maple Syrup.
Producers or Jobbers, D. B. Scully Syrup Co., Chicago, Ill.
Retailers, Hogen & Foltz, Bottineau, N. D.
Not properly labeled.
Illegal.

Lab. No. 1804.
Brand, Maple Syrup.
Sent in by E. Adamson.
Not propertly labeled. Illegal.

Lab. No. 2001.
Brand, Maple Syrup, Green Mountain.
Producers or Jobbers, Towle Maple Syrup Co., St. Paul, Minn.
Retailers, Chas. Full, Pembina, N. D.
Not properly labeled. Illegal.

Lab. No. 2006.
Brand, Canada Sap.
Producers or Jobbers, National Syrup Co., St. Paul, Minn.
Retailers, Fargo Merc. Co., Fargo, N. D.
Not properly labeled. Illegal.

Lab. No. 2018.
Brand, Maple syrup, Monarch.
Producers or Jobbers, Reid Murdoch & Co., Chicago.
Retailer, A. D. Sprague, Devils Lake, N. D.
Not properly labeled. Illegal.

Lab. No. 2050.
Brand, Maple Syrup, Ottawa.
Producers or Jobbers, Western Maple Co., St. Paul.
Retailer, Muus Bros., Minot, N. D.
Mainly glucose. Illegal.

Lab. No. 2135.
Brand, Scudder's Maple Syrup.
Producers or Jobbers, Scudder Syrup Co.
Retailer, H. G. Sprague, Grafton, N. D.
Not properly labeled. Illegal.

Lab. No. 2166.
Brand, Maple Syrup, Green Mountain.

Producers or Jobbers, Towle Syrup Co., St. Paul, Minn.
Retailers, Chicago Store, Harvery, N. D.
Not properly labeled. Illegal.

Lab. No. 2329.
Brand, Maple Syrup, Lyndon.
Producers or Jobbers, Franklin MacVeach & Co., Chicago.
Retailers, Jos. Purdon & Co., Wahpeton, N. D.
Not proprely labeled. Illegal.

Lab. No. 2330.
Brand, Maple Syrup, Richelieu.
Producers or Jobbers, Sprague Warner & Co., Chicago.
Retailers, Star Grocery Co., Wahpeton, N. D.
Not properly labeled. Illegal.

Lab. No. 2371.
Brand, Maple Syrup, Monarch.
Producers or Jobbers, Reid Murdoch & Co., Chicago.
Retailers, W. E. Daniels, Valley City, N. D.
Not pure maple syrup. Illegal.

Lab. No. 2563.
Brand, Aunt Kates Green Mountain.
Producers or Jobbers, Truesdell Syrup Co., Freeport, Ill.
Retailers, The Pinkerton Kellogg Co., Lakota, N. D.
Not properly labeled. Illegal.

Lab. No. 2625.
Brand, Old Moose.
Producers or Jobbers, Arcadia Maple Co., address not given.
Retailer, Albert Larson, Cooperstown, N. D.
Not properly labeled. Illegal.

Lab. No. 2642.
Brand, Old Moose.
Producers or Jobbers, Arcadia Maple Co.
Retailers, F. L. Stanley & Son, Casselton, N. D.
Not properly labeled. Illegal.

Lab. No. 2679.
Brand, Aunt Kates Green Mountain.
Producers or Jobbers, Truesdell Syrup Co., Freeport, Ill.
Retailers, L. A. Brooks & Co., Larimore, N. D.
Not properly labeled. Illegal.

Lab. No. 2686.
Brand, Old Moose.
Producers or Jobbers, Arcadia Maple Co.
Retailers, W. L. Forkner, Wahpeton, N. D.
Not properly labeled. Illegal.

Lab. No. 2791.
Brand, Maple Syrup, Canada Sap, Old Moose.
Producer or Jobber, Arcadie Maple Co., address not given.
Retailers, Stone, Ordean, Wells Co., Duluth, Minn.
Not proprely labeled. Illegal.

Lab. No. 2795.
Brand, Maple Sugar.
Producer or Jobber, Arcadia Sap Co., St. Francosi, Canada.
Retailer, Fargo Mercantile Co., Fargo.
Not proprely labeled. Illegal.

MEATS AND MEAT PRODUCTS.

During the past few months considerable attention has been given to an examination of meats, as found in the markets, to determine to what extent sulphites and borates or coal tar dye was being employed. The result of our investigation proved a surprise with regard to the amount of sulphites and borates employed especially in sausages, bolognas, hamburger steak, minced ham, etc. We further found that fully 95 per cent of the shops in the state were using some form of preservative containing either sulphites or borates. The commercial products most generally used was Freezem, iceine, preservaline or some similar product containing the same ingredients in varying proportions. The large packers were promptly notified that the use of these chemicals was not permitted under the terms of our food law. It may be said to the credit of Libby, McNeil & Libby that they took steps to correct any violation of the food law even before the same went into effect. Armour & Company and the Armour Packing Company, as soon as notified, manifested a desire to have their goods in compliance with the law and promptly adjusted any difference as soon as their attention was called to the matter. The other large packers have taken steps to comply with the law, and it is believed that no further differences will arise with these houses regarding the use of unnatural chemical preservatives in the preparation of meat products offered for sale in this state.

Personal notice has been served on the butchers in nearly all the larger towns warning them to discontinue the use of Freezem, iceine, preservaline, Bull meat flour, Konservirungs Salze, and all un-natural products used for preserving or coloring meats and meat products. Newspaper notices and letters of warning were frequently made but largely without avail. The butchers urged on by the manufacturers of these chemicals, seemed determined to persist in their use and it became necessary to take active steps to put a stop to the practice and as a further preliminary warning five butchers in Fargo were prosecuted for selling sausages and hamburger steak containing sulphites or borates. Each party pleaded guilty and paid his fine. Later the examination of meats sold in the larger towns of the state revealed the fact that the use of these chemicals was still common. It was then decided to push prosecutions vigorously until the state was rid of all doctored or so called "embalmed meats." This work is still in progress and will be vigorously conducted. Thus far 22 butchers have been prosecuted for violation of the food law.

The question is asked as to the amount of these preservatives present in meats. In ham, dried beef, and like cured products we have found from 5 to 15 grains of boric acid per pound of meat. In sausages, bolognas, hamburger steak, etc., we have found from 20 grains to 50 grains of boric acid per pound. As to the affect of boric acid and of the borates, I quote the following from the New Hampshire Sanitary Bulletin for July 1904.

INFLUENCE OF BORIC ACID AND BORATES ON DIGESTION AND HEALTH.

"The physiological effects following the ingestion of borax in small quantities, such as are employed in preserving food, have ben discussed by various authors, and their conclusions are so varied as to be of little value. One of the latest articles, which has bene accepted as reliable, discusses the subject as follows: "As the antiseptic action of boric acid is small, comparatively large quantities are necessary to preserve articles of food, and it is quite possible for a person to take as much as three grammes, or 46 grains, daily in his ordinary food." The author insists that his "assimilation experiments which were carried on, on dogs, cats, rabbits, and on four assistants in his laboratory, showed positively that the use of borax and boric acid interferes with the absortion of food and causes the excretion of an abnormally large amount of nitrogen. He believes it is demonstrated that large doses of boric acid reduces the body weight and that the excretion of these substances from the body is so slow that their accumulation in the body is probable. Borax and boric acid cause diuresis, which may produce damage of the kidneys; they may cause skin eruptions which indicate nutritive disturbances; they may produce diarrhoea; they interfere with the normal absorption of food; and they may produce vomiting."

The conclusion is that the use of boron compounds in food should be forbidden.

Dr. Wiley, of the Bureau of Chemistry, Department of Agriculture sums up the result of his investigations with the influence of boric acid and borax in foods on digestion and health as follows:

"While many of the individual data obtained are contradictory, the general results of the investigation secured by combining into single expressions all the data relating to each particular problem studied show in a convincing way that even in doses not exceeding half a gram (7 1-2 grains) a day boric acid and borax equivalent thereto are prejudicial when consumed for a long time. It is undoubtedly true that no patent effects may be produced in persons of good health by the occasional use of preservatives of this kind in small quantities but the young, the debilitated, and the sick must not be forgotten and the safe rule to follow is to exclude these preservatives from foods of general consumption."

In the light of all the data at hand no one would longer consider the use of these preservatives as harmless.

THE USE OF SODUIM SULPHITES IN MEATS.

Our own studies with sausages and hamburger steak indicates that from 0.20 per cent to 0.50 per cent or more of sulphites are employed in these meats. As to the harmfulness of these products a recent article by Dr. Harrington of Harvard Medical College entitled "Sodium Sulphite, A Dangerous Food Preservative" gives the results of his investigations, and from this we quote the following:

"It (Sodium Sulphite) is classed as a food preservative, but its antiseptic properties are comparatively feeble. It is used more especially on account of its effect on the appearance of the food to which it is added, its preservative influence being decidedly a minor consideration. It confers upon minced meat (chopped meat) an abnormally brilliant red color, which conveys to the purchaser the idea of freshness. * * * * Persisting as it does, meat which is in reality well advanced in decomposition is readily disposed of as perfectly fresh, for although the number of bacteria per gram may run as high as 500 millions, it may give off no marked odor. It may fairly be said that, on account of its masking decomposition, it is an undesirable admixture."

Certainly then, with these facts before us we do not believe that the people of North Dakota wish to allow the indiscriminate use of these drugs or chemicals in their food products, placed there by men who do not know the nature of the products employed by them and who are not always careful in determining the amount used.

The following standards are laid down for food control work:

PRESERVED MEATS. Ham, bacon, dried beef, and canned meats should be preserved by smoke desiccation, salt and sterlization only.

SAUSAGES. "Sausages are finely divided or hashed meats mixed with spices and flavoring. They may be cooked or uncooked and are usually encased in skins." The chemical standard is as follows: The water should be below 50 per cent, and free from starch, chemical preservatives and coloring.

Below I give the result of our examinations for meats found to be illegal from containing either borates or sulphites:

MEATS—ILLEGAL.

Lab. No. 1844.
Brand, Dried Beef, Armour's Sliced Star.
Producer and Jobber, Armour & Co., Chicago.
Retailer, T. E. Yerxa, Fargo, N. D.
Contains borates.

Lab. No. 1852.
Brand, Sliced Beef, Diamond C. Brand.
Producers or Jobbers, Cudahy Packing Co.
Retailer, Fargo Grocery Co., Fargo, N. D.
Contains borates.

Lab. No. 1921.
Brand, Sliced Bacon, Libby's.
Producers or Jobbers, Libby, McNeill & Libby, Chicago.
Retailer, J. C. Carwright & Co., Dickson, N. D.
Contains borates.

Lab. No. 1997.
Brand, Sliced Dried Beef, Rex.
Producers or Jobbers, Cudahy Packing Co.
Retailer, Chas. Full, Pembina, N. D.
Contains borates.

Lab. No. 2070.
Brand, Potted Ham, Rex.
Producers or Jobbers, Cudahy Packing Co., Omaha.
Retailers, Parazeek & Maach, Lidgerwood, N. D.
Contains alumna salts.

Lab. No. 2076.
Brand, Sliced Dried Beef, White Label.
Producer or Jobber, Armour Packing Co., Kansas City.
Retailer, J. A. Kotchian, Lidgerwood, N. D.
Contains borates.

Lab. No. 2132.
Brand, Breakfast Bacon, Gold.
Producer or Jobber, Armour Packing Co., Kansas City.
Retailer, Chas. Moore & Son, Grafton, N. D.
Contains borates.

Lab. No. 2253.
Brand, Chicken Loaf, Rex.
Producer or Jobber, Cudahy Canning Co., Omaha.
Retailer, Johnson & Nisbet, Grand Forks, N. D.
Contains borates.

Lab. No. 2254.
Brand, Sliced Bacon, Diamond C.
Producer or Jobber, Cudahy Packing Co.
Johnson & Nisbet, Grand Forks, Retailer.
Contains borates.

Lab. No. 2258.
Brand, Sliced Beef, Diamond C.
Producer or Jobber, Cudahy Packing Co., Omaha.
Retailer, C. N. Howard, Grand Forks, N. D.
Contains borates.

Lab. No. 2377.
Brand, Sliced Beef, Diamond C.
Producer or Jobber, Cudahy Packing Co.
Retailer, Fargo Grocery Co., Fargo, N. D.
Contains borates.

Lab. No. 2388. (By request.)
Brand, Sliced Bacon, Diamond C.
Producer or Jobber, Cudahy Packing Co., Omaha.
From Company.
Contains borates.

Lab. No. 2418.
Brand, Breakfast Bacon, Gold.
Producer or Jobber, Armour Packing Co., Kansas City.
Retailer, Hillis Manning Co., Bathgate, N. D.
Contains borates.

Lab. No. 2422.
Brand, Bologna.
Retailer, Holmes Brighton & Co., Neche, N. D.
Contains borates.

Lab. No. 2451.
Brand, Sausage Meat.
Retailer, C. E. Green, Fargo, N. D.
Contains boracic acid.

Lab. No. 2452.
Brand, Sausage Meat.
Retailer, Central Meat Market, Larson & Stalheim, Fargo.
Contains suphites in large amount.

Lab. No. 2454.
Brand, Hamburger Steak, Bulk.
Retailer, Hauser Bros., Fargo. N. D.
Contains sulphites.

Lab. No. 2455.
Brand, Sliced Dried Beef, Rex.
Producer or Jobber, Cudahy Packing Co.
Retailer, Hauser Bros., Fargo, N. D.
Contains borates in large amount.

Lab. No. 2460.
Brand, Bologna Sausage.
Producer or Jobber, Swift & Co., Chicago.
Retailer, C. E. Green, Fargo, N. D.
Contains borates.

Lab. No. 2462.
Brand, Sausage Link.

Retailer, Central Meat Market, Larsen & Stalheim, Fargo, N. D.
Contains borates.

Lab. No. 2468.
Brand, Hamburger Steak.
Retailer, C. F. Eggert, Fargo, N. D.
Contains sulphites.

Lab. No. 2469.
Brand, Sausage Meat.
Retailer, C. F. Eggert, Fargo, N. D.
Contains borates.

Lab. No. 2470.
Brand, Bologna Sausage.
Producer or Jobber, Cudahy Packing Co.
Retailer, C. F. Eggert, Fargo, N. D.
Contains borates.

Lab. No. 2471.
Brand, Bologna Sausage.
Retailer, C. F. Eggert, Fargo, N. D.
Contains borates.

Lab. No. 2481.
Brand, Bologna Sausage.
Producer or Jobber, Swift & Co., Chicago.
Retailer Johnson & Nelson, Fargo, N. D.
Contains borates.

Lab. No. 2490.
Brand, Bologna Sausage.
Producer or Jobber, Armour & Co., Chicago.
Retailer, Sam Roberg, Fargo, N. D.
Contains boracic acid or borates.

Lab. No. 2491.
Brand Canvas Sausage.
Producer or Jobber, Swift & Co., Chicago.
Retailer, Baldwin & Johnson, Fargo, N. D.
Contains borates.

Lab. No. 2581. (By request.)
Brand, Sausage.
Retiler, Geo. R. Freeman, Fargo, N. D.
Contains a large amount of borates.

Lab. No. 2590.
Brand, Vienna Sausage, Red Star Brand.
Producer or Jobber, Cicero Canning Co., Chicago.
Retailer, Geo. R. Freeman, Fargo, N. D.
Contains borates.

Lab. No. 2634.
Brand, Sausage Meat.
Retailer, Michael Gass, Larimore, N. D.
Contains sulphites.

Lab. No. 2635.
Brand, Sausage Meat Bulk.
Retailer, Cash Meat Market, Casselton, N. D.
Contains sulphites.

Lab. No. 2637.
Brand, Sausage Meat.
Retailer, F. L. Stanley & Son, Casselton, N. D.
Contains sulphites.

Lab. No. 2638.
Brand, Hamburger Steak.
Retailer, F. L. Stanley & Son, Casselton, N. D.
Contains sulphites.

Lab. No. 2647.
Brand, Sausage Meat.
Retailer, Peter F. Werstlein, Grand Forks, N. D.
Contains sulphites.

Lab. No. 2648.
Brand, Sausage Meat.
Retailer, Stewart Bros., Grand Forks, N. D.
Contains sulphites.

Lab. No. 2649.
Brand, Sausage Meat.
Retailer, E. Fields & Co., Grand Forks, N. D.
Contains sulphites.

Lab. No. 2651.
Brand, Sausage Meat.
Retailer, J. E. McLaren & Co., Hillsboro, N. D.
Contains sulphites.

Lab. No. 2652.

Brand, Sausage Meat.
Retailer, Chas. Hempel, Hillsboro, N. D.
Contains sulphites.

Lab. No. 2681.

Brand, Sausage Meat.
Retailer, W. H. Willardt, Wahpeton, N. D.
Contains sulphites.

Lab. No. 2682.

Brand, Pork Sausage Meat.
Retailer, Eder Bros., Wahpeton, N. D.
Contains borates in considerable amount.

Lab. No. 2683.

Brand, Pork Sausage Meat.
Retailer, Frank Benda, Wahpeton, N. D.
Contains sulphites.

Lab. No. 2684.

Brand, Hamburger Steak.
Retailer, Frank Benda, Wahpeton, N. D.
Contains sulphites.

Lab. No. 2691.

Brand, Sausage Meat.
Retailer, Blackmore & Hamm, Jamestown, N. D.
Contains sulphites in large amount.

Lab. No. 2693.

Brand, Sausage Meat.
Retailer, Charles Kurtz, Jamestown, N. D.
Contains borates.

Lab. No. 2707.

Brand, Sausage Meat, Pork.
Retailer, John Wager, Bismarck, N. D.
Contains sulphites.

Lab. No. 2708.

Brand, Sausage Meat.
Retailer, Geo. Gussner, Bismarck.
Contains a large amount of sulphites.

Lab No. 2709.
Brand, Sausage. Links.
Retailer, Geo. Gussner, Bismarck, N. D.
Contains sulphites in considerable amount.

Lab. No. 2710.
Brand, Sausage Meat, Bulk.
Retailer, J. C. Sweet, Bismarck, N. D.
Contains sulphites in large amount.

Lab. No. 2711.
Brand, Sausage Meat.
Retailer, Glittschka Bros., Bismarck, N. D.
Contains sulphites in large amount.

Lab. No. 2712.
Brand, Bologna Sausage.
Retailer, Giltschka Bros., Bismarck, N. D.
A fair reaction for borates.

Lab. No. 2723.
Brand, Sausage Meat.
Retailer, F. W. Cockborn, Devils Lake, N. D.
Sulphites present in large amount.

Lab. No. 2734.
Brand, Sausage Meat, Pork.
Retailers, James Algeo. Valley City, N. D.
Contains sulphites in large amount.

Lab. No. 2737.
Brand, Sausage Meat, Pork.
Retailer, City Meat Market, F. R. Schultze, Valley City, N. D.
Contains sulphites in large amount.

PRUNES AND OTHER DRIED FRUITS.

Silver and Ruby prunes have been condemned for the reason that our examinations of these products show them all to contain large quantities of sulphurous acid or sulphites. As to the desirability of eating foods charged with these products I refer the reader to what is said on this subject under the head of meats.

Silver and Ruby prunes are simply Black prunes picked before they are ripe and treated to a very heavy sulphuring, which changes the color of the skin, bringing all to a uniform shade of color and leaving quantities of the acid in the fruit. A later publication will discuss more fully the character of these products and the amount of the sulphites present.

Much of the California bleached fruit has been treated in a like manner but not to the same extent. One of the leading California shippers in writing concerning Ruby prunes says as follows: "They are not treated to sulphur fumes to a greater extent than any other variety of dried fruits shipped from California." My own examinations of the other fruits do not warrant this sweeping assertion. The fruit should be marketed, however, in its natural condition and the public educated to demand such products. The definition laid down for dried fruits is as follows: "Dried fruits should not contain worms and be free from zinc, lead, bleaching agents, etc."

This we take to be the standard under the terms of the food law of this state.

DRIED FRUITS—ILLEGAL.

Lab. No. 1842.

Brand, Seeded Raisins, Monogram.
Producer or Jobber, J. B. Inderriedden Co., Fresno, Cal.
Retailer, T. E. Yerxa, Fargo, N. D.
Contains borates.

Lab. No. 2157. (By request.)

Brand, Seeded Raisins, Monogram.
Producer or Jobber, J. B. Inderrieden Co., Fresno, Cal.
From Company at Chicago.
Contains borates.

Lab. No. 2158. (By request.)

Brand, Seeded Raisins, Monogram.
Producer or Jobber, J. B. Inderrieden Co., Fresno, Cal.
Contains borates.

Lab. No. 2293. (By request.)

Brand, Seeded Raisins, Monogram.
Producer or Jobber, J. B. Inderrieden & Co., Fresno, Cal.
Retailer, at Fargo.
Contains borates.

Lab. No. 2294.
Brand, Seeded Raisins, Guardian Brand.
Producer or Jobber, Rosenberg Bros. & Co., San Francisco, Cal.
Retailer, Farmer's Supply House, Fargo.
Contains borates.

Lab. No. 2578. (By request.)
Brand Ruby Prunes.
Jobbers, Park, Grant & Morris, Fargo, N. D.
Contains sulphites in large amount.

Lab. No. 2594.
Brand, Dried Apricots.
Retailers, Hughes & Thue, Fargo, N. D.
Contains sulphites in large amount.

Lab. No. 2604.
Brand, Ruby Prunes.
Retailer, E. A. Perry, Fargo, N. D.
Contains sulphites.

Lab. No. 2607.
Brand Evaporated Apricots, Bulk.
Retailer, O. S. Hadeland, Fargo, N. D.
Sulphites present.

Lab. No. 2608.
Brand, Evaporated Peaches, Bulk.
Retailer, O. S. Hadeland, Fargo, N. D.
Contains sulphites.

Lab. No. 2617.
Brand, Peaches, (Dried.)
Retailer, T. E. Yerxa, Fargo, N. D.
Sulphites present.

Lab. No. 2619.
Brand, Ruby Prunes.
Retailer, T. E. Yerxa, Fargo, N. D.
Contains sulphites in large amount.

Lab. No. 2620.
Brand, Apricots, dried.
Producers or Jobbers, Griffin & Sekelly Co., California.
Retailer, T. E. Yerxa, Fargo, N. D.
Contains sulphites.

Lab. No. 2640.
Brand, Silver Prunes.
Retailer, Knight Stanley Finney Co., Casselton, N. D.
Contains sulphites.

Lab. No. 2653.
Brand, Silver Prunes, Bulk.
Retailer, P. S. Peterson, Hillsboro, N. D.
Contains sulphites.

Lab. No. 2658.
Brand, Silver Prunes, Bulk.
Retailer, G. P. Feihn, Hillsboro, N. D.
Contains sulphites.

Lab. No. 2666.
Brand, Silver Prunes.
Retailer, L. A. Brooks & Co., Larimore, N. D.
Contains sulphites.

Lab. No. 2685.
Brand, Silver Prunes.
Retailer, A. E. McKean & Co., Wahpeton, N. D.
Contains sulphites.

Lab. No. 2730. (By request.)
Brand, Ruby Prunes.
Retailer, Leach, Gamble, Dexter & Co., Wahpeton, N. D.
Contains sulphites.

Lab. No. 2731. (By request.)
Brand, Ruby Prunes.
Retailer, Leach, Gamble, Dexter & Co., Wahpeton.
Contains sulphites.

Lab. No. 2732. (By request.)
Brand Silver Prunes.
Retailer, Farmer's Supply House, Fargo.
Contains sulphites.

Lab. No. 2783.
Brand, Ruby Prunes.
Retailer, Box Car Merchant, Lisbon, N. D.
Contains sulphites.

Lab. No. 2787. (By request.)
Brand, Ruby Prunes.

Retailer, J. H. Allen & Co., St. Paul.
Contains sulphites.

Lab. No. 2792.
Brand, Dried Fruit, Peach.
Retailer, Box Car Merchant, Petersourg, N. D.
Contains sulphites.

CORN AND SUCCOTASH.

When our food law went into effect nearly all of the corns were the bleached product, containing sulphites in varying amounts, in some goods saccharin was present as the sweetening agent and in a few cases preservatives were also found in the corn. Soaked corn was not at all uncommon and many cans were found to contain starch as a thickner. Much of this has been changed. The standard brands of the west are now generally free from both sulphites and saccharin. Too many of the cheaper products are still "sloppy" and are thickened with corn starch. It seems to me that such goods are to be condemned for it is no less a fraud than many other commercial frauds now generally condemned; such as the misbranding of preserves, syrups, etc., which the public are not willing to longer tolerate.

With a little more publicity it is believed that these adulterated products will be wholly driven from the markets in this state and we shall see onee more the natural food products canned and offered to the public.

In this state there has been a marked tendency the present year to depend less upon store goods than formerly. Families have canned and dried the products of the garden for winter consumption. Such a course will soon cause a change in the method of putting up canned foods, and a purer, more wholesome and better grade of goods will be furnished for consumption. I can testify to the excellent quality of some of the home prepared products, notably corn, peas and string beans.

CORN AND SUCCOTASH—ILLEGAL.

Lab. No. 1262.
Brand, Sweet Corn Extra, Monarch.
Producers or Jobbers, Reid Murdoch & Co., Chicago.
Retailer, Fargo Grocery Co., Fargo.
Contains saccharin.

Lab. No. 1268.

Brand, Cream Succotash, U. S.
Producer or Jobber, U. S. Canning Co., Fredonia.
Retailer, Lewis Vidger, Loomis Co., Fargo, N. D.
Contains saccharin and also sulphite.

Lab. No. 1274.

Brand, Sugar Corn, Alice Rose.
Producer or Jobber, Fernald Keene & True Co., West Poland, Me.
Retailer, Foley Bros. & Kelly, St. Paul, Minn.
Contains saccharin.

Lab. No. 1290.

Brand, Sugar Corn, Glenwood.
Producer or Jobber, New Glenwood Canning Co., Glenwood, Ia.
Retailer, Foley Bros. & Kelly, St. Paul, Minn.
Contains saccharin.

Lab. No. 1357.

Brand, Corn, Bengal.
Producer or Jobber, Griggs, Cooper & Co., St. Paul, Minn.
Retailer, A. Finnesetth, Park River, N. D.
Contains saccharin.

Lab. No. 1386.

Brand, Sugar Succotash, Cream, Dinner Party.
Producer or Jobber, Orchard Park Canning Co., Orchard Park, N. Y.
Retailer, Benner, Begg & Garver, Grand Forks, N. D.
Sweetened with saccharin.

Lab. No. 1425.

Brand, Sweet Corn, Extra, Monarch.
Producer, Reid, Murdoch & Co., Chicago.
Retailer, Fargo Grocery Co., Fargo, N. D.
Sweetened with saccharin.

Lab. No. 1790.

Brand, Corn, Whynot.
Producer or Jobber, Griggs, Cooper & Co., St. Paul, Minn.
Retailer, Hogen & Foltz, Bottineau, N. D.
Sweetened with saccharin.

Lab. No. 1884.
Brand, Maine Sugar Corn, Orange Blossom.
Producer or Jobber, J. & E. A. Wyman, Bethel, Me.
Retailer, Michelson Mercantile Co., Bismarck, N. D.
Contains sulphites.

Lab. No. 2042.
Brand, Sugar Corn, Pride of Talbot.
Producer or Jobber, Farmer's Co., Op. Packing Co., Easton, Md.
Retailer, Nash Bros., Grand Forks, N. D.
Contains sulphites.

Lab. No. 2359.
Brand, Cream Corn, Golden.
Producer or Jobber, Wm. McKinley Canning Co., Lenox, N. Y.
Retailer, O. Simonson, Valley City, N. D.
Contains sulphites.

Lab. No. 2582.
Brand, Sugar Corn.
Producer or Jobber, unknown.
Retailer, Gowan-Peyton, Twohy Co., Duluth, Minn.
Contains sulphites.

CANNED BEANS.

Quite a number of samples of beans have been examined and found to contain saccharin. In a few instances preservatives have been found and in some cases more than one had been used. We have found saccharin, benzoic acid and salicylic acid in the same samples. In some instances the saccharin may have been responsible for the salicylic acid. I am convinced, however, that, in not a few cases with various food products we have passed samples containing chemical preservatives where several have been employed in the same sample, hoping in this way, to mislead the chemist. A slight amount of each of several products might be employed so that the full preservative strength desired would be secured and yet there would not be enough of any single one present to furnish a decided reaction. In this way a few samples have escaped being condemned but in most instances we have a record which will enable us to follow up the work in the future.

Lab. No. 1257.
Brand, White Wax Beans, Monarch.
Producers or Jobber, Reid, Murdoch & Co., Chicago.
Retailers, Fargo Grocery Co., Fargo, N. D.
Contains salicylic acid.

Lab. No. 1266.
Brand, Refugee Beans, Shield.
Producers or Jobbers, J. D. Farren & Co., Baltimore.
Retailers, Lewis, Vidger, Loomis Co., Fargo, N. D.
Contains saccharin.

Lab. No. 1298. (By Request.)
Brand, White Wax Beans, Fort Snelling.
Producers or Jobbers, Foley Bros. & Kelly, St. Paul, Minn.
Retailers,
Contains saccharin.

Lab. No. 1301.
Brand, Refugee String Beans, Pride of Rome.
Producers or Jobbers, Olney Bros., Rome, N. Y.
Retailers, Fargo Grocery Co., Fargo, N. D.
Contains saccharin.

Lab. No. 1311. (By Request.)
Brand, Stringless Beans, Fort Snelling.
Producers or Jobbers, Foley Bros. & Kelly, St. Paul, Minn.
From. Co.
Contains saccharin.

Lab. No. 1315.
Brand, Extra String Beans, Monarch.
Producers or Jobbers, Reid, Murdoch & Co., Chicago.
Retailers, Fargo Grocery Co., Fargo, N. D.
Contains saccharin.

Lab. No. 1323.
Brand, Golden Wax Beans, Pride of Rome.
Producers or Jobbers, Olney Bros., Rome, N. Y.
Retailers, Fargo Grocery Co., Fargo, N. D.
Contains saccharin.

Lab. No. 1359.
Brand, Refugee Stringless Beans, Pride of Rome.
Producers or Jobbers, Olney Bros., Rome, N. Y.
Retailers, Fargo Grocery Co., Fargo, N. D.
Contains saccharin.

Lab. No. 1378.
Brand, Refugee Beans, Nokomis.
Producers or Jobbers, Stone, Ordean, Wells & Co., Duluth, Minn.
Retailers, Benner, Begg & Garvin, Grand Forks, N. D.
Sweetened with saccharin.

Lab. No. 1486.
Brand, Refugee Beans, Best Value.
Producers or Jobbers, Chautauqua Preserving Co., Irving, N. Y.
Retailers, Schweitzer Bros., Cavalier, N. D.
Contains saccharin.

Lab. No. 2259.
Brand, Beans, (Haricots Flageolets.)
Producer or Jobber, Alphonse Pinaud, Bordeaux, France.
Retailer, R. B. Griffith, Grand Forks, N. D.
Contains copper in large amount.

Lab. No. 2623. (By Request.)
Brand, Beans.
Producers or Jobbers, Burt Olney Canning Co., Oneida, N. Y.
Retailers, Jones & Williams, Minneapolis, Minn.
Contains saccharin, salicylic acid and benzoic acid.

Lab. No. 2624. (By Request.)
Brand, Beans.
Producers or Jobbers, Burt Olney Canning Co., Oneida, N. Y.
Retailers, Jones & Williams, Minneapolis.
Contains saccharin, benzoic acid and salicylic acid.

CANNED PEAS AND FRENCH PEAS (PETIT POIS.)

Very few of the ordinary canned peas have been found to be adulterated as brought into the state during the past year. A few have contained saccharin the use of which product is prohibited in all food products. The state has not been wholly free, however, from soaked peas and this line of products will be looked after more closely in the future. Such products to be legal must be clearly and distinctly marked as "Soaked Peas."

French Peas (Petit Pois) are very common in the markets and only recently have we been able to give attention to this class of food products. As shown by the following report the French peas are very generally treated to copper so as to green them. Food products so treated are not to be commended and it would be well for the public to discontinue the use of so-called French peas which have been treated with copper or aluminum salts. In my experience the small sifted American peas is much to be preferred as an article of diet to the foreign one, which, it is said, is not always correctly labeled with regard to place of production. My advice is to leave these products alone for a time and a superior product will soon be supplied. It is very questionable whether the French peas *as furnished in this country* is as popular in France as it is in America.

PEAS ILLEGAL.

Lab. No. 1227.
Brand, Early June Peas, Sweet Wisconsin.
Producer or Jobber, The Reynolds Preserving Co., Sturgeon Bay, Wis.
Retailer, Lewis, Vidge, Loomis Co., Fargo, N. D.
Contains saccharin.

Lab. No. 1253.
Brand, Petits Pois (French Peas.)
Producer or Jobber, Green de Laitre & Co., Minneapolis. Minn. (?)
Retailer, Fargo Grocery Co., Fargo, N. D.
Contains copper, also alum salts.

Lab. No. 1261.
Brand, Early June Peas, Extra, Monarch.
Producer or Jobber, Reid, Murdoch & Co., Chicago.
Retailer, Fargo Grocery Co., Fargo, N. D.
Contains borates.

Lab. No. 1272.
Brand, French Peas.
Producer or Jobber, Geo. R. Bard, Bordeaux, France.
Retailer, Foley Bros. & Kelly, St. Paul, Minn.
Artifically colored with copper and alum salts.

Lab. No. 1273.
Brand, French Peas, Jules Dupont.
Retailer, Foley Bros. & Kelly, St. Paul, Minn.
Contains copper and alum salts.

Lab. No. 1527.
Brand, Extra Early June Peas, Monarch.
Producer or Jobber, Reid, Murdoch & Co., Chicago.
Retailer, Fargo Grocery Co., Fargo, N. D.
Contains borates.

Lab. No. 1520.
Brand, Early June Peas, Honey Dew.
Producer or Jobber, Erie Preserving Co., Buffalo, N. Y.
Retailer, Rathman Bros., Jamestown, N. D.
Contains saccharin.

Lab. No. 1812.
Brand, Petit Pois, Home.
Made in France, Bordeaux.
Retailer, Pure Food Store, Fargo, N. D.
Contains copper.

Lab. No. 1848.
Brand, Petit Pois.
Producers or Jobbers, George Dalidet & Co., Bordeaux, France.
Retailer, T. E. Yerxa, Fargo, N. D.
Contains copper.

Lab. No. 1912.
Brand, French Peas.
Producer or Jobber, Griggs, Cooper & Co., St. Paul, Minn.
Contains aluminum salts.

Lab. No. 1923.
Brand, Petits Pois.
Producer or Jobber, J. F. Barbet & Cie, Dounarneuz, France.
Retailer, J. C. Cartwright Co., Dickinson, N. D.
Contains copper.

Lab. No. 1959.
Brand, Petit Pois.
Producer or Jobber, C. Couteaux.
Retailer, T. E. Yerxa, Fargo, N. D.
Contains copper.

Lab. No. 1960.
Brand, Petit Pois.
Producer or Jobber, B. Fouga, Bordeaux, France.
Retailer, M. Lang Grocery Co., Mandan, N. D.
Contains copper.

Lab. No. 1995.
Brand, Petit Pois.
Producers or Jobber, R. Monbadon, Bordeaux, France.
Retailer, Chas. Full, Pembina, N. D.
Contains aluminum and copper.

Lab. No. 2112.
Brand, Petits Pois.
Producer or Jobber, Jules Fastier & Cie, Bordeaux, France.
Retailer, H. E. Wheeler & Co., Minot, N. D.
Contains copper.

Lab. No. 2115.
Brand, Petits Pois (French Peas.)
Producer or Jobber, Victor Tertrais, Nantes, France.
Retailer, McKone Bros., Minot, N. D.
Contains copper.

Lab. No. 2142.
Brand, Petit Pois.
Producer or Jobber, Le Soliel, Malines, Belgium.
Retailer, H. G. Sprague, Grafton, N. D.
Contains copper.

Lab. No. 2187.
Brand, Petits Pois (French Peas,) Risch.
Producer or Jobber, Ancienne, Maison, Risch & Cheminant, Paris.
Contains copper and aluminum.

Lab. No. 2188.
Brand, Petits Pois (French Peas,) Risch.
Producer or Jobber, Ancienne, Maison & Cheminant, Paris.
Retailer, R. J, Pratt, Harvey, N. D.
Contains copper and aluminum.

Lab. No. 2194.
Brand, Petits Pois.
Producer or Jobber, Paul Bergot & Fils.
Retailers, Chicago Store, Harvey, N. D.
Contains copper and aluminum.

Lab. No. 2230.
Brand, Petit Pois.
Producer or Jobber, B. Laforest, Periqueux, France.
Retailer, Benner, Begg & Garvin, Grand Forks, N. D.
Contains copper and aluminum.

Lab. No. 2247.
Brand, Petits Pois, (French Peas.)
Producers or Jobbers, Geo. Dalidet & Co., Bordeaux, France.
Retailer, Colton Bros., Grand Forks, N. D.
Contains copper.

Lab. No. 2263.
Brand, Petits Pois.
Producer or Jobber, C. Couteaux, Paris.
Retailer, Geo. H. Wilder, Grand Forks, N. D.
Contains copper.

Lab. No. 2280.
Brand, Petits Pois, Le Soliel.
Made at Malines, France.
Retailer, M. W. Hansen & Co., Grand Forks, N. D.
Contains copper and aluminum salts.

Lab. No. 2281.
Brand, Petits Pois.
Producer or Jobber, R. Monbadon, Bordeaux.
Retailers, M. W. Hansen & Co., Grand Forks, N. D.
Contains copper and aluminum salts.

Lab. No. 2285.
Brand, Petits Pois.
Producers or Jobbers, Geo. Dalidet & Co., Bordeaux, France.
Retailers, Colton Bros., Grand Forks, N. D.
Contains copper.

Lab. No. 2286.
Brand, Petits Pois.
Producers or Jobbers, Geo. Dalidet & Co., Bordeaux, France.
Retailers, Colton Bros., Grand Forks, N. D.
Contains copper and aluminum salts.

Lab. No. 2287.
Brand, Petits Pois.
Producers or Jobbers, R. Monbadon, Bordeaux, France.
Retailers, Colton Bros., Grand Forks, N. D.
Contains copper.

Lab. No. 2378.
Brand, French Peas (Petits Pois.)
Producer or Jobber, C. Couteaux.
Retailers, Fargo, Grocery Co., Fargo, N. D.
Contains copper and aluminum salts.

Lab. No. 2421.
Brand, French Peas.
Producer or Jobber, R. Monbadon, Bordeaux, France.
Retailers, Murphy, Holmes & Co., Neche, N. D.
Contains copper and aluminum salts.

MUSHROOMS (CHAMPIGNONS.)

A few brands of mushrooms have been examined and in nearly all cases found to be badly bleached, and to contain large amounts of sulphurous acid and sulphites. The contents of many cans were only the stems of the mushrooms but with nothing on the label to show this fact. In many cases the mushrooms themselves were of very inferior quality. In some instances the appearance would indicate that the canned product had been produced from a dried mushroom soaked, steamed and bleached I do not say that this is true of some of the best brands, while the flavor of nearly all of these mushrooms was very far from that of the fresh grown product. We condemned one of the well known brands and the matter was by the jobbers referred to the New York importers. We give the letter of the jobbers as expressing the views of the importers on this point.

"Some time since you condemned some mushrooms which we had sent to a customer at Wahpeton. We referred this letter to the importers of those mushrooms, and today we get their reply, saying that this was the first time in their experience (and they have been in business a good many years,) that there has been any trouble with mushrooms. They say further that all mushrooms that are packed for the American trade are bleached in a similar manner to which those you condemned were, and that if they were not bleached the American consumers would not buy them. In other words, they would not use mushrooms in the natural state, like they are packed for the French trade. They say that the bleaching process makes them look white, but that the American people who use them do not care for the flavor, so that they look right. They say that it will be impossible for any importer to handle mushrooms in any other shape than that they are now. Under these circumstances we would like to ask you what if any action you are going to take with regard to them."

This would seem to indicate that the American people depend upon the appearance of food products and care little for flavor, while the French prefer their food products in the natural state and prize the flavor rather than the appearance.

It might further be assumed that the products bleached and furnished to this country are those not acceptable to the French palate. Would it not be better if we depended more on flavor and purity and less on unnatural appearance? Would not the cultivating of such a taste result in bringing us a higher grade of food products and furnished in their natural condition? I must, however, differ from the views expressed in the foregoing letter regarding the tastes of the Amrican people, at least, those with whom it has been my good fortune to be associated with in this line of work.

MUSHROOMS ILLEGAL.

Lab. No. 1509.
Brand, Champignon's (Mushrooms.)
Producer or Jobber, Couteaux, Paris.
Retailer, Fargo Grocery Co., Fargo.
Contains sulphites.

Lab. No. 1873.
Brand, Home, Mushrooms.
Retailers, Pure Food Store, Fargo.
Contains sulphites.

Lab. No. 1875.
Brand, Mushrooms.
Producer or Jobber, Maurice & Cie, Paris, France.
Retailer, W. H. McIntosh & Co., Bottineau.
Contains sulphites.

Lab. No. 1911. (By request.)
Brand, Imported Mushrooms.
Producer or Jobber, Griggs, Cooper & Co., St. Paul.
Contains sulphites.

Lab. No. 1933.
Brand, Mushrooms.
Producer or Jobber, Laroze, Paris.
Retailer, Geo. Drenkel, Dickinson, N. D.
Contains sulphites.

Lab. No. 1942.
Brand, Mushrooms.

Producer or Jobber, Louis Genet & Cie, Bordeaux, France.
Retailer, W. B. Haight, Mandan, N. D.
Contains sulphites.

Lab. No. 1943.
Brand, Gopher, Mushrooms.
Producer or Jobber, R. Bouteut Freres, Bordeaux, France.
Retailer, W. B. Haight, Mandan.
Contains a trace of sulphites.

Lab. No. 2246B.
Brand, Mushrooms.
Producer or Jobber, Geo. Dalidet & Co., Bordeaux, France.
Retailer, Colton Bros., Grand Forks, N. D.
Contains sulphites.

Lab. No. 2265.
Brand, Mushrooms.
Producer or Jobber, C. Couteaux, Paris.
Retailer, Geo. H. Wilder, Grand Forks, N. D.
Contains sulphites.

Lab. No. 2282.
Brand, Mushrooms.
Producer or Jobber, P. Roland & Cie, Paris.
Retailer, M. W. Hanson & Co., Grand Forks.
Contains sulphites.

Lab. No. 2288.
Brand Mushrooms (Boutons Extra.)
Producer or Jobber, Geo. Dalidet & Co., Bordeaux, France.
Retailer, Colton Bros., Grand Forks, N. D.
Contains sulphites.

Lab. No. 2320.
Brand, Mushrooms.
Producer or Jobber, P. Roland & Cie, Paris.
Retailer, Sitar & Huppeler, Wahpeton, N. D.
Contains sulphites.

Lab. No. 2325.
Brand, Mushrooms.
Producer or Jobber, Charles Voilleque, Bordeaux, France.
Retailer, Star Grocery, Wahpeton, N. D.
Contains sulphites.

Lab. No. 2379.
Brand, Mushrooms, Extra.
Producer or Jobber, Geo. Dalidet & Co., Bordeaux.
Retailer, Fargo Grocery Co., Fargo.
Contains sulphites.

COCOAS AND CHOCOLATES.

During the past summer an examination of cocoas and chocolates was undertaken and a large number of these were found to be adulterated with cereals as shown by the foreign starch. Several of the companies protested that their products were not adulterated. In marked contrast to this was the frank statement received from the Rockwood & Co., of New York whose products were comparatively free from foreign products as compared with those from many other firms. I quote from their letter:

"We are not going to, in any way, dispute these analysis, as we feel that they are just and correct, as we have shipped goods that contained 10 per cent of cereal to your state and we feel that it is very possible that the samples picked up by you are of this class of goods. But we will take a little of your time to explain to you the condition and why you have found cereal in our Premium Chocolate.

"Until quite recently the word Premium Chocolate meant, in the minds of manufacturers, a mixture of chocolate and a small per cent of cereal, prepared for use in households, and was so made by all the manufacturers for a great many years, but recently there have been many cheap manufacturers who have abused this formula to such an extent that it has forced us to take a different stand and that is to make Premium chocolate with nothing but the products of the cocoa bean with nothing added, which we have been doing for some time; and to prove further our feeling in the matter, we wish to say that a representative from our house was one of the committee that waited on Prof. Wiley of the Federal Pure Food Law and who suggested to him a definition for Premium chocolate that would force all manufacturers to make a piece of Premium chocolate of all cocoa bean and if they decided to put any cereal, to so mark it on the outside of the package, by calling it a compound.

"We refer to this, simply to show you that it has never been our intention to serve the public with an adulterated piece of Premium Chocolate."

Would it not have been more honorable for some of the other houses to have taken a similar course rather than to have denied the fact and then tacitly admit it by withdrawing the product from the state and replacing the same with a brand marked 100 per cent pure, and which did comply with the law.

In passing it may be said that we have never found a sample of Walter Baker's products which did not comply with the law. The Rockwood Company, as stated above, have placed their goods right. William Baker Co., and the W. H. Baker Co., have replaced their goods in the state with products marked 100 per cent pure. This last statement is made to show that these companies now have goods complying with the law.

COCOA AND CHOCOLATES, ILLEGAL.

Lab. No. 1774.
Brand, Chocolate, Justice Premium No. 1.
Producer or Jobber, William H. Baker, Syracuse, N. Y.
Retailer, Fargo Mercantile Co., Fargo.
Contains a large amount of foreign starch.

Lab. No. 1784.
Brand, Chocolate, Justice.
Producer or Jobber, Wm. H. Baker, Syracuse, N. Y.
Retailer, G. K. Vikan, Bottineau, N. D.
Contains foreign starch.

Lab. No. 1819.
Brand, W. H. Baker's Chocolate.
Producer or Jobber, W. H. Baker, Winchester, Va.
Retailer, Gate City Provision Co., Fargo, N. D.
Contains foreign starch.

Lab. No. 1950.
Brand, Premium No. 1, Chocolate.
Producer or Jobber, W. H. Baker, Winchester, Va.
Retailer, W. B. Haight, Mandan.
Contains foreign starch.

Lab. No. 1954. (By request.)
Brand, Deutsche, Sweet Chocolate.
Producer or Jobber, Wm. H. Baker, Syracuse, N. Y.
A large amount of foreign starch.

Lab. No. 1989.
Brand, Home, Chocolate.

Producer or Jobber, Griggs, Cooper & Co., St. Paul.
Retailer, Schweitzer Bros., Cavalier, N. D.
Contains foreign starch filler.

Lab. No. 1989B.
Brand, Ambrosia, Sweet Chocolate.
Producer or Jobber, Ambrosia Chocolate Co., Milwaukee, Wis.
Retailer, J. P. Branchaud, Pembina, N. D.
Contains starch.

Lab. No. 1990.
Brand, Rockwood & Co., Premium, Chocolate.
Producer or Jobber, Rockwood & Co., New York.
Retailer, E. R. Pratt, Cavalier, N. D.
Contains a large amount of foreign starch.

Lab. No. 2045.
Brand, Red Hook, Chocolate.
Producer or Jobber, Red Hook Chocolate Co., Red Hook, N. Y.
Retailer, P. P. Lee, Minot, N. D.
Contains a large amount of foreign starch.

Lab. No. 2077.
Brand, Best, Sweet Chocolate.
Producer or Jobber, W. H. Baker, Winchester. Va.
Retailer, J. A. Kotchian, Lidgerwood. N. D.
Contains a large amount of foreign starch.

Lab. No. 2114.
Brand, Walkers Mascot, Sweet Chocolate.
Producer or Jobber, John Walker & Co., Brooklyn.
Retailer, Peter Ehr, Minot.
Contains large amount of starch.

Lab. No. 2146.
Brand, Premium, Chocolate.
Producer or Jobber, Rockwood & Co., New York.
Retailer, Chas. Moor & Son, Grafton, N. D.
Contains a large amount of foreign starch.

Lab. No. 2164. (By request.)
Brand, Noxall, Chocolate Covering.
Producer or Jobber, H. O. Wilbur & Sons, Philadelphia.
Contains large amount of starch.

Lab. No. 2215.
Brand, Daisy, Sweet Chocolate.
Mfg. unknown.
Retailer, N. E. Brown, Buffalo.
Contains foreign starch.

Lab. No. 2216.
Brand, Justice, Cocoa.
Producer or Jobber, Wm. H. Baker, Syracuse, N. Y.
Retailer, H. D. Ruettell & Co., Buffalo.
Contains large amount of starch.

Lab. No. 2223.
Brand, Elephant, Sweet Chocolate.
Mfg. unknown.
Retailer, E. Kanouse, Tower City, N. D.
Contains large amount of foreign starch.

Lab. No. 2227.
Brand, Fry's Homoepathic Cocoa.
Producer or Jobber, J. S. Fry & Sons, Britton & London.
Retailer, W. W. King, Tower City, N. D.
Contains large amount of foreign starch.

Lab. No. 2527.
Brand, Unsweetened Baking Chocolate.
Producer or Jobber, Manhattan Cocoa & Chocolate Mills, N. Y.
Retailer, J. A. Blegen, Hickson, N. D.
Contains foreign starch.

BEVERAGES.

But very litle attention has been given as yet to the examination of beverages, soda fountain supplies, etc. From the examinations made it is believed that there is need for some work in this direction. As will be observed some of the porte wines are far from pure as are also blackberry brandies or cordials.

The majority of the samples examined have been done at the request of interested parties. It is expected that this line of work will be reached during the next few months and an attempt made to have these products put in compliance with the food law before another summer.

In justice to the manufacturers of Grape Vino it should be said that this company, on being notified that their product was not in compliance with the law, immediately took steps to put the product right and of late we have no complaint to make. The same should be said for the Glenwood Spring Water Co's products. In fact this company was the first to take up the matter with a request that a full line of their products be examined in order that they might find where they were in violation and so be able to correct the character of the products. Recent tests made for the Company have shown a marked improvement and products now in compliance with the law of the state in case of the particular samples tested.

BEVERAGES—ILLEGAL.

Lab. No. 1383.
Brand, Blackberry Brandy.
Producer or Jobber, Schlaberg & Griffin, Grand Forks, N. D.
Colored with coal tar dye and an artificial product.

Lab. No. 1431.
Brand, Blackberry Brandy.
Producer or Jobber, Patten Pharmacy, Grand Forks, N. D.
Colored with coal tar dye.

Lab. No. 1442. (By request.)
Brand, Port Wine, No. 4.
Producer or Jobber, Lyman Eliel Drug Co., Minneapolis, Minn.
Colored with coal tar dye.

Lab. No. 1577.
Brand, Apple Cider, Johnson's.
Retailer, Fargo Grocery Co., Fargo, N. D.
Contains salicylic acid.

Lab. No. 1620. (By request.)
Brand, Old Preserved Port Wine.
Producer or Jobber, Severne Wine Co., Severne-on Senica, N. Y.
Contains coal tar dye.

Lab. No. 1654. (By request.)
Brand, Wild Cherry.
Producer or Jobber, Glenwood Springs Water Co., Glenwood, Minn.
Colored with coal tar dye.

Lab. No. 1655. (By request.)
Brand, Root Beer.
Producer or Jobber, Glenwood Springs Water Co., Glenwood, Minn.
Sweetened with saccharin and colored with coal tar dye.

Lab. No. 1674. (By request.)
Brand, Porte Wine.
Producer or Jobber, Lyman Eliel Drug Co., Minneapolis.
Colored with coal tar dye.

Lab. No. 1781.
Brand, Grape Vino.
Producer or Jobber, James McIntosh Co., Minneapolis, Minn.
Retailer, G. H. Casavaw, Bottineau, N. D.
Colored with coal tar dye.

Lab. No. 1782.
Brand, Blackberry Brandy.
Retailer, Sims & Kilbourn, Bottineau, N. D.
Contains coal tar dye, saccharin and salicylic acid.

Lab. No. 1798. (By request.)
Brand, Grape Vino.
Producer or Jobber, Jas. McIntosh & Co., Minneapolis, Minn.
Colored with coal tar dye.

Lab. No. 2257.
Brand, Concord Grape Juice.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Retailer, K. M. Ness & Co., Grand Forks, N. D.
Contains benzoic acid.

Lab. No. 2404.
Brand, Grape Vino.
Retailer, C. A. Hawkins, Hillsboro, N. D.
Colored with coal tar dye.

Lab. No. 2436. (By request.)
Brand, Birch Beer.
Producer or Jobber, Glenwood Spring Water Co., Glenwood, Minn.
Contains salicylic acid, and coal tar dye.

Lab. No. 2437. (By request.)
Brand, Wild Cherry Wine.

Producer or Jobber, Glenwood Spring Water Co., Glenwood, Minn.
Contains salicylic acid and coal tar dye.

Lab. No. 2439. (By request.)
Brand, Pear Champaign Cider.
Producer or Jobber, Glenwood Spring Water Co., Glenwood, Minn.
Contains salicylic acid and coal tar dye.

Lab. No. 2483.
Brand, Concord Grape Juice.
Producer or Jobber, Reid Murdoch & Co., Chicago.
Contains benzoic acid.

CATSUPS.

A catsup to be legal should be made from ripe tomatoes with the necessary sweetening and condiments, but should be free from coal tar dyes, or vegetable colors unless so labeled, and free from starch paste, saccharin, or other vegetable products other than that derived from the whole tomato.

The following is the list examined and found to be in violation of the law. There has been a very marked improvement in the catsups and but few of the better known brands are found to be in violation of the law. Often these samples may have been from old stock or products reshipped from other states where the laws are less stringent.

No attempt seems to have been made by the producers of the Minnesota Favorite Tip Top Ketchup or of Booth's to put these products so as to comply with the law and from the first have been found continuously wrong.

CATSUPS—ILLEGAL.

Lab. No. 1571.

Brand, Tomato Catsup, Van Camp's.
Producers or Jobbers, Van Camp Packing Co., Indianapolis, Ind.
Retailers, Grand Forks Mercantile Co., Grand Forks, N. D.
Colored with coal tar color.

Lab. No. 1595
Brand, Ketchup Tomato, Butler's.
Producers or Jobbers, The Tip Top Ketchup Co., Cincinnati, O.
Retailers, Bismarck Grocery Co., Bismarck, N. D.
Colored with coal tar color.

Lab. No. 1867.
Brand, Fulton.
Producers or Jobbers, Fulton Relish Co., Indianapolis, Ind.
Retailers, W. H. McIntosh & Co., Bottineau, N. D.
Colored with coal tar color and contains filler-starch.

Lab. No. 1868.
Brand, Minnesota Favorite.
Producers unknown. (Gedney, Pickling Co.?)
Retailers, W. H. McIntosh & Co., Bottineau, N. D.
Colored with coal tar dye, also large amount of filler starch.

Lab. No. 1944.
Brand, Booth's.
Producers or Jobbers, Booth & Co., Baltimore, Md.
Retailers, Badger & Pollard, Mandan, N. D.
Contains a quantity of starch colored with coal tar color.

Lab. No. 2003.
Brand, Tomato Catsup, Manhattan Club.
Producers or Jobbers, The Tip Top Catsup Co., Cincinnati, O.
Retailers, F. S. Cheney, Pembina, N. D.
Colored with coal tar dye. Contains starch.

Lab. No. 2063.
Brand, Tomato Catsup, Reliable.
Producers or Jobbers, Reliable Ketchup Co., Hamilton, Ohio
Retailers, Prazcek & Maack, Lidgerwood, N. D.
Contains starch paste, colored with coal tar dye.

Lab. No. 2072.
Brand, Tomato Catsup, Home Made.
Producers or Jobbers, Standard Packing Co., Indianapolis. Ind.
Retailers, R. Fisher, Lidgerwood, N. D.
Colored with coal tar dye.

Lab. No. 2073.
Brand, Tomato Ketchup, Tip Top.

Producers or Jobbers, Tip Top Ketchup Co., Cincinnati, O.
Retailer, B. Fisher, Lidgerwood, N. D.
Contains coal tar dye and starch.

Lab. No. 2248.
Brand, Tomato Catsup, Home Comfort.
Producers or Jobbers, Brant Canning Co., Brant, N. Y.
Retailers, Colton Bros., Grand Forks, N. D.
Colored with coal tar color.

Lab. No. 2266.
Brand, Tomato Catsup, Home Made.
Producers or Jobbers, Standard Packing Co., Indianapolis.
Retailers, Geo. H. Wilder, Grand Forks, N. D.
Colored with coal tar colors.

Lab. No. 2296.
Brand, Tomato Catsup, Snider's Home Made.
Producers or Jobbers, A. Snider Preserving Co., Cincinnati, O.
Retailers, Farmers' Supply House, Fargo, N. D.
Colored with coal tar color.

Lab. No. 2352.
Brand, Tomato Catsup, Minnesota Favorite.
Producers or Jobber, Gedney, Pickling Co., Indianapolis.
Retailers, O. Simonson, Valley City, N. D.
Colored with coal tar color and contains large amount of starch.

Lab. No. 2409B.
Barnd, Wagner's Dogshead.
Producers or Jobbers, Martin Wagner Co., Baltimore, Md.
Retailers, Bismarck Grocery Co., Bismarck, N. D.
Colored with coal tar dye.

Lab. No. 2579. (By request.)
Brand, Tomato Catsup.
Retailers, Dow & Draper, Duluth, Minn.
Contains starch and foreign color.

Lab. No. 2663.
Brand, Minnesota Favorite. (Gedney Pickling Co?)
Retailer, Thos. Regan, Larimore, N. D.
Colored with coal tar color.

LEMON EXTRACT ILLEGAL.

A lemon extract to be legal must contain 5 per cent of lemon oil, be free from coal tar colors, and of good and alcoholic strength.

Lab. No. 1438.
Brand, Seely's.
Producers, Seely Mfg. Co., Detroit, Mich.
Retailers, Benner, Begg & Garvin, Grand Forks, N. D.
Oil of Lemon, 2.20 per cent.
Color foreign.

Lab. No. 1480.
Brand, Cuitoit.
Producers, The Cuitoit Co., Chicago.
Oil of Lemon, 0 per cent.
Color foreign.

Lab. No. 1794.
Brand, Lemon Extract.
Producer, unknown.
Retailer, Covell & Co., Skyeston, N. D.
Oil of Lemon, 3.47 per cent.
Contains Methyl alcohol.

Lab. No. 1928.
Brand, Atwood & Steele's Double.
Producers, Atwood & Steele, Chicago.
Retailers, Dickinson Mercantile Co., Dickinson, N. D.
Oil of Lemon, 2.83 per cent.
Color natural.

Lab. No. 2052.
Brand, Pure Concentrated.
Producers, J. H. Bell & Co., Chicago.
Retailers, McKone Bros., Minot, N. D.
Oil of Lemon, 3.09 per cent.
Color questionable.

Lab. No. 2150.
Brand, Jumbo.
Producers, W. M. Hoyt & Co., Chicago.
Retailer, M. Rasmusson, Inkster, N. D.
Oil of Lemon, 2.18 per cent.
Color foreign.

Lab. No. 2159.
Brand, Lemon Extract.
Producers, Consolidated Perfume Co., Chicago.
Oil of Lemon, 2.89 per cent.

Lab. No. 2170.
Brand, Jewetts High Grade.
Producers, Jewett Bros., Aberdeen, S. D.
Retailers, Gackle & Billigmeier, Harvey, N. D.
Oil of Lemon, 2.06 per cent.

Lab. No. 2184.
Brand, Atwood & Steele's.
Producers, Atwood & Steele, Chicago.
Retailers, E. Hunger & Son, Hankinson, N. D.
Oil of Lemon, 3.61 per cent.

Lab. No. 2228. (By request.)
Brand, Coronet.
Producer, California Citrus Product Co., National City, Cali.
Oil of Lemon, 0 per cent.

Lab. No. 2310.
Brand, Otter Triple.
Producers, Beall & McGowan Co., Fergus Falls, Minn.
Retailers, Marcus Peschem, Wahpeton.
Oil of Lemon, 0 per cent.
Color foreign.

Lab. No. 2315.
Brand, Hoosier.
Producers, Atwood & Steele, Chicago.
Retailer, D. D. Swank, Wahpeton, N. D.
Oil of Lemon, 1.47 per cent.
Color foreign.

Lab. No. 2389.
Brand, Bastine's.
Producers, Bastine & Co., New York.
Oil of Lemon, 4.50 per cent.

Lab. No. 2446.
Brand, Lemon Extract.
Producer, unknown.
Retailers, J. O. Rourke Co., Mandan, N. D.
Oil of Lemon, 3.25 per cent.

Lab. No. 2448.
Brand, Lemon Extract.
Retailers, J. O'Rouke, Co., Mandan, N. D.
Oil of Lemon, 3.25 per cent.

Lab. No. 2667.
Brand, Seal.
Producers, Kenwood Preserving Co., Chicago.
Retailer, Thos. Regan, Larimore, N. D.
Oil of Lemon, 0 per cent.
Color foreign.

VANILLA—ILLEGAL.

Lab. No. 1682.
Brand, Banquet.
Producers, Geo. R. Newell & Co., Minneapolis, Minn.
Retailers, Chas. T. Studness, Churches Ferry, N. D.
A purely synthetic product, not properly labeled, foreign color.

Lab. No. 1792.
Brand, Vanilla Extract.
Retailers, Covell & Co., Sykeston, N. D.
A very weak extract colored with foreign color.

Lab. No. 1876.
Brand, Special Compound.
Producers, Lakota Mfg. Co., Chicago, Ill.
Retailers, Hans Holtan & Sons, Washburn.
Artificial product, colored.

Lab. No. 2014.
Brand, Quacker.
Producers, Quaker Extract Co., Chicago.
Retailer, P. DeFeore, Devils Lake, N. D.
An artificial product of coumarin and colored.

Lab. No. 2029.
Brand, Dieter's Double.
Producer, J. P. Dicter & Co., Chicago.
Retailer, J. M. Yoder, Fargo, N. D.
Artificially colored and a synthetic product.

Lab. No. 2160.
Brand, Vanilla Extract.
Producer, Heafner & Heafner, Elmira, N. Y.

Retailer, Mrs. May Duerner, Fargo, N. D.
An artificial product of coumarin and Vanillin, Colored.

Lab. No. 2162.
Brand, Vanilla Solid.
Producers, Heafner & Heafner, Elmira, N. Y.
Retailer, Mrs. May Duerner, Fargo, N. D.
A synthetic product from vanillin.

Lab. No. 2174.
Brand, Pure Food.
Producers, Standard Chemical Co., St. Louis, Mo.
Retailer, Wm. Grawe, Hankinson, N. D.
An artificial product of coumarin and colored with carmel.

Lab. No. 2239. (By request.)
Brand, Big A.
Producers, J. H. Allen & Co., St. Paul, Minn.
Purely synthetic, colored.

Lab. No. 2276.
Brand, Diamond.
Producers, Kelly Mfg. Co., Chicago.
Retailers, K. M. Ness & Co., Grand Forks, N. D.
A synthetic product, foreign color.

Lab. No. 2316.
Brand, Atwood & Steele.
Producers, Atwood & Steele, Chicago.
Retailer, D. D. Swank, Wahpeton, N. D.
Foreign color and not official.

Lab. No. 2317.
Brand, Hoosier.
Producers, Atwood & Steele, Chicago.
Retailer, D. D. Swank, Wahpeton, N. D.
Not an official preparation.

Lab. No. 2505. (By Request.)
Brand, Perfection.
Producers, Atwood & Steele, Chicago.
Contains a foreign color.

CREAM OF TARTAR.

A considerable portion of the bulk cream of tartar sold in this state has been found to be badly adultereated, to have as its basis alum, and in some instances to be a mixture of alum and phosphates or of alum and sulphates and sulphites. In several instances jobbers have withdrawn the adulterated product from trade and replaced it with a pure product. It is evident that as yet we can not depend on securing a pure product in the bulk form. Retailers are warned against handling this class of goods and should buy only from houses willing to furnish a guarantee that the cream of tartar furnished by them will comply with the pure food law of this state.

CREAM OF TARTAR—ILLEGAL.

Lab. No. 1713.

Brand, Cream Tartar, Bulk.
Producer, Unknown.
Retailer, Otto J. Doebler, Crystal, N. D.
Mainly alum.

Lab. No. 1878.

Brand, Cream Tartar, Bulk.
Retailer, F. Johnson & Co.
Mainly alum.

Lab. No. 1881.

Brand, Cream Tartar, Bulk.
Producers or Jobbers, Jewett Bros., Aberdeen, S. D.
Retailers, Gackle, Koth & Schultz, Washburn, N. D.
Largely alum.

Lab. No. 1982.

Brand, Cream of Tartar, Bulk.
Retailer, Rudolph Evingson, Kindred, N. D.
Contains alum.

Lab. No. 2078.

Brand, Bulk.
Retailer, J. A. Kotchian, Lidgerewood, N. D.
Contains alum and phosphates.

Lab. No. 2079.
Brand, Acid Phosphate.
Retailer, Parizeek & Maack, Lidgerwood, N. D.
Contains alum and phosphates.

Lab. No. 2138.
Brand, Bulk.
Retailers, Erie & Moe, Grafton, N. D.
Contains large amount of lime sulphite.

Lab. No. 2177.
Brand, Bulk.
Producers or Jobbers, Jewett Bros., Aberdeen, S. D.
Retailers, Gackle & Billingmeier, Harvey, N. D.
Contains alum and phosphates.

Lab. No. 2212.
Brand ,Bulk.
Retailer, Star Grocery, Fargo, N. D.
Contains alum and phosphates.

Lab. No. 2214.
Brand ,Bulk.
Retailer, H. E. Brown & Co., Buffalo, N. D.
Contains alum and phosphates.

Lab. No. 2222.
Brand ,Bulk.
Retailer, E. Kanouse, Tower City, N. D.
Contains alum and phosphates.

Lab. No. 2249.
Brand ,Bulk.
Retailer, C. H. Howard, Grand Forks, N. D.
Contains alum and phosphates.

Lab. No. 2292.
Brand ,Bulk.
Reailers, Hughes & Thue, Fargo, N. D.
Contains alum and phosphates.

Lab. No. 2333.
Brand ,Bulk.
Retailers, Kraabel & Kraabel, Colgate, N. D.
Contains alum and phosphates.

Lab. No. 2351.
Brand ,Bulk.
Retailers, Weiser & Kelly, Valley City, N. D.
Contains alum and phosphates.

SOME ADULTERATIONS AND FRAUDS IN THE FOOD MARKETS.

BY E. F. LADD, FOOD COMMISSIONER, NORTH DAKOTA.

(Presented before the International Pure Food Congress and Convention of Dairy and Food Departments at St. Louis.)

In discussing the subject which has been assigned me "Some Adulterations and Frauds in the Food Markets," it is not my purpose or desire at this time to advertise the houses who manufacture these goods, but rather to point out some of the frauds which I have found to exist among food products and beverages offered for sale in North Dakota. In discussing the subject of adulteration and frauds I shall do so from the standpoint as Food Commissioner for North Dakota, and under the law as it exists in that state. There are three essential principles laid down in the law of the state:

First: The use of chemical preservatives, including saccharin is prohibited.

Second: The use of all coal tar colors is prohibited, as well as all other colors where their use is intended to abet deception and fraud.

Third: The label should tell the truth, or as our friends in South Dakota have said, the label should tell the truth, the whole truth and nothing but the rtuth.

All goods which do not comply with the requirements of this law which it seems to me is a natural law, are necessarily classed as adulterated or misbranded, and therefore come well within the subject which has been assigned me for treatment. There was hardly a product offered for sale in the state one year ago but what some brands were found to be adulterated, and in some instances the adulteration and fraud had become so general that it was well neigh impossible to find a pure product, as competition had practically driven these from the state.

MEATS.

One might suppose that the meats offered for sale in the state would be generally pure and true to name, but while potted chicken and potted turkey are common products, I have never yet found a can in the state which really contained in determinable quantity either chicken or turkey.

More than 90 per cent of the local meat markets in the state were using chemical preservatives and in nearly every butcher shop could be found a bottle of Freezem, preservaline or iceine, as well as Bull Meat Flour. The amount of borax or boracic acid employed in these meats varied to a considerable extent, and expressed in terms of boracic acid in sausages and Hamburger steak would probably range from 20 grains to 45 grains per pound, while the medical dose is from 5 to 9 grains per day. The use of these chemicals is not confined to the local butchers, scarcely a ham could be found that did not contain borax. In the dried beef, in the smoked meats, in the canned bacon, in the canned chipped beef, boracic acid or borates is a common ingredient. Certainly it can not be said that the use of this preservative is necessary in goods sealed in glass and tin, whatever may be said with regard to their use in other classes of meats. Probably sodium sulphite is more generally used than any other preservative in sausages and hamburger steak by the local butcher. At times the meat which he employs in the preparation of these products is tainted and the use of sulphites helped him to dispose of such meats as ripened products.

Canned salmon was frequently found to contain borates in varying quantity, and while many of the canners protested that they were not using borates, nevertheless, it was shown that the special salt, sold them for use, contained sufficient borax to act as a preservative agent. We quote from a letter of a prominent packer on the coast: "The analysis made by one of the packers in this city, showed that your statements in regard to this borax was true although the packer, himself, has never purchased an ounce of borax. * * * It was found that the salt contained the borax." This same class of salt has been sold to dairy men at a fancy price, with the statement that because it was so highly purified from foreign matter, the butter in which this salt was used would keep indefinitely.

FRENCH PEAS.

Ninety per cent of the so called French Peas which we have taken up in North Dakota were found to contain copper salts in varying quantities, and in a few samples in addition to the copper salts there were present aluminum salts. Inasmuch as we were unable to reach by letter a number of the alleged canners it is probably true that the majority of samples examined were put up in this country.

MUSHROOMS

Of all the canned mushrooms on the market in North Dakota 85 per cent were found to be bleached by the use of sulphites. Our examinations do not seem to show that any definite rule was followed by the canners of these goods with regard to the amount of sulphur or sulphites used. In some instances the contents of the can proved to be nothing better than the discarded stems of mushrooms, but there was nothing to show this on the labels.

CATSUPS.

When the food law went into effect in North Dakota there was but one brand of catsup, so far as I am able to find by my records which was pure, that is, free from chemical preservatives and coal tar coloring matters. Many of the catsups offered for sale in the state were made from the waste products from canners—pulp, skins, ripe tomatoes, green tomatoes, starch paste in considerable quantity, coal tar colors, chemical preservatives, usually benzoate of soda or, salicylic acid, the whole highly spiced and not always free from saccharin. In other instances the basis for the catsup was largely pumpkin. I consider the use of starch paste in the manufacture of catsup as a fraud, and that its use should be condemned.

I have found tomatoes in cans with all the appearance of being ripe, but in reality the cans were filled mainly with green tomatoes, tomato pulp, and coal tar dye. In same cans less than 12 per cent of the contents failed to pass through a good grade of cheese cloth. The use of coloring matter—coal tar dye—alone permitted of the practice of such frauds.

COCOA AND CHOCOLATE.

Of cocoas and chocolates examined, about 70 per cent have been found to be adulterated. Until very recently not a sample marked as Premium Chocolate was found which did not contain from 10 to 90 per cent of foreign matter. At times the cheaper grade of this product would have some flavoring matter such as synthetic vanilla added to improve their quality. The better grades of the Premium Chocolates contained from 10 to 20 per cent of cereals. Some samples have been so badly adulterated that the beverage made from them would never be suspected of having been produced from the cocoa bean.

Of the sweet chocolates, many of them were no better. The Elephant and the Daisy brandas were among the worst found in the state, so bad, in fact, that the manufacturers seemed ashamed to attach their name, and yet it would not be strange if the products could be traced back, like many other food products which are badly adulterated, and without the name of the manufacturer, through some house which poses as a friend of pure foods. Our laws ought to make prohibitory the sale of any food product which did not bear the name of the manufacturer, or which bore a fictitious name, as is so often the case with goods of low grade. This leads me to consider certain goods bearing such names. A letter mailed to the Reliable Catchup Co. at Hamilton, Ohio, is sure to be returned to you; while the post master informs you that there is no such party or manufacturing establishment known in that city. I suppose from the nature of the product the manufacturers are ashamed to give their true names and address. Another instance of this kind is the Mineiska Packing Co., Mineiska, Minn. This is a little hamlet in Minnesota and there is no packing company of any kind there, and the corn packed under this label is bleached with sulphites and sweetened with saccharin. A letter addressed to the Quaker Extract Co., Chicago, is sure to be returned, and the extracts produced by them and sold in North Dakota are artificial products colored in imitation of the genuine article. The Western Maple Co., of St. Paul, Minn., is another concern, at one time in existance, but at the present time is unknown to the post-master in that city, nevertheless, their labels of the Ottawa Brand of maple syrup are still used by some of the well known houses. The syrup under this label is a mixture of cane sugar and glucose. If we address the Kenwood Preserving Co., of Chicago, the letter is sure to be returned for lack of proper address, yet their goods have been very abundant in North Dakota. These are cases where manufacturers seem to be ashamed of the products which is given the public, and so prefer to hide the fraud under the name of some irresponsible concern or with fictitious names. This list might be largely multiplied, and in fact there are houses who are posing as friends of pure food, nevertheless, under some fictitious name are sending out goods in violation of the food laws of the northwest. Some of the biggest frauds have their headquarters in St. Louis, and these include the manufacturers of various ciders which at the Chicago World's Fair won gold medals for the superior product produced. The Cherry Cider, for instance, does not contain, so far as I am able to find, a single product which was ever in any way affiliated with the cherry tree. It is made of acids, flavored with chemical ethers, colored with coal tar dye, and chemically preserved. This product has been freely advertised and sold as one of the pure food products of the country.

While we are speaking of beverages, we might well consider the matter of Porte Wine, for there are a large number of thse on the market which are very far from being a desirable product, and in North Dakota there have been wines ranging all the way from products of the highest grade of purity to the imitation product made from cheap alcohol, colored with coal tar dye, preserved with salicylic acid, with added sugar for sweetness, sometimes saccharin and chemicals for flavor. These products have been sold at the drug stores, and presumably are not infrequently prescribed by the practioneer for some convalescent patient who requires the use of such a beverage in the purest form. The makers and sellers of these products should be behind the penitentiary bars rather than being permitted to parade before the public as responsible citizens, and to enter into competition with reputable manufacturers of wines and brandies, whose goods in some sections have been entirely driven out of the market being unable to meet the competition with these spurious articles.

TDE AMOUNT OF SODIUM SULPHITE RECOVERABLE FROM PRESERVED MEATS AND EVAPORATED FRUITS, AS A BASIS FOR THE ESTIMATION OF THE AMOUNT ORIGINALLY PRESENT.

O. D. HOLLEY.

PART I. ESTIMATION OF SODIUM SULPHITE IN MEATS.

At a time when so many misleading statements are being made concerning sodium sulphite and sulphurous acid as food preservatives and the amounts actually used in the preservation of meats and the bleaching of fruits, it is necessary, in order to form an impartial judgment, to make a careful investigation of the subject and collect such experimental data as it is possible for us to secure. This paper is a result of the investigations carried out in the Food Laboratory of the North Dakota Experiment Station.

Some writers would have us believe sodium sulphite is always used in very small quantities. Dr. Calm in his recent pamphlet "Sulphurous Acid and Sulphites as Food Preservatives," when discussing Harrington's statement that sodium sulphite confers upon minced meat an abnormally brilliant red color says, "This is not true of the very small amounts of sodium sulphite actually employed on meat, e. g., 0.075 per cent." Again further on in the same article he states, "When it is considered that only 0.075 per cent of sodium sulphite is added to meat to preserve it, and that 76 per cent to 96 per cent of this is oxidized to sulphate before the meat is eaten, and that from the remaining per cent of sulphurous acid, the amount of sulphurous acid naturally present in meat, (.0047-0.01 per cent) must be deducted, the moiety of free sulphurous acid left in meat preserved by sulphites, is rather startling to those who claim that sodium sulphite as a food preservative is deleterious to health."

In order to determine the accuracy of these statements the following experiments were carried out. The sodium sulphite was added to freshly prepared pork sausage and determinations of the amounts recovered, calculated from the sulphurous acid distilled over, were made, after allowing the meat to stand for the various lengths of time.

TABLE I.

AMOUNTS OF SODIUM SULPHITE RECOVERED.

100 grams pork sausage mixed with 0.2 per cent sodium sulphite	After 6 hours	After 24 hours	After 36 hours	After 3 days
1	49.75	32.43	23.06	23.28
II	26.15	30.85	25.10	22.81
III	33.15	31.75	24.16	22.11
IV	.....	.....	.....	22.45
Average	36.35	31.68	24.11	22.66

Out of forty-three samples of pork sausage and hamburger steak collected at different butcher shops throughout the state by Prof. E. F. Ladd, Food Commissioner, thirty contained sulphites; of this number, eighteen were examined quantitatively and the following amounts of sodium sulphite, calculated from the sulphurous acid, were recovered. All of the samples were at least thirty-six hours old when analyzed and the majority of them were considerably older, as they had developed the odor of standing meat. Assuming from the above data that as much as one-fourth of the sodium sulphite was recovered, which is stating it very conservatively, the minimum per cent originally present is given in the last column of the following table.

TABLE II

100 g. of the samples were treated with phosphoric acid in usual manner	Amount of sodium sulphite recovered, grains	Minimum per cent originally present
Lab. Number 2634	0.1315	0.53
Lab. Number 2635	0.356	1.42
Lab. Number 2636	0.3515	1.41
Lab. Number 2637	0.0294	0.37
Lab. Number 2638	0.131	0.52
Lab. Number 2648	0.0494	0.20
Lab. Number 2649	0.1206	0.48
Lab. Number 2651	0.361	1.44
Lab. Number 2652	0.0356	0.14
Lab. Number 2681	0.0951	0.38
Lab. Number 2683	0.0931	0.37
Lab. Number 2691	0.0894	0.36
Lab. Number 2707	0.137	0.45

Lab. Number 2708	0.054	0.22
Lab. Number 2710	0.0758	0.30
Lab. Number 2711	0.023	0.09
Lab. Number 2734	0.044	0.18
Lab. Number 2737	0.0385	0.15
Average	0.1265	0.50

In not a single instance, was as low a per cent found as Dr. Calm states in his article. In three cases nearly *twenty times* the amount stated, was found while the average was nearly *seven times* the amount Dr. Calm would have us believe is being used to "embalm" meat.

In order to ascertain the amount recoverable when varying amounts of sodium sulphite were used with the same quantity of sausage, the following experiments were carried out. The meat stood four days after being treated with the sulphite. The distillates were collected in two portions.

TABLE III.

100 grams meat used	Per cent distillate 50 cc.	Per cent distillate 100 cc.	Total per cent recovered
I 220 g. sodium sulphite	16.94	6.07	23.01
II 300 g. sodium sulphite	11.81	6.90	18.71
III 400 g. sodium sulphite	18.98	3.56	22.54
IV 500 g. sodium sulphite	17.90	4.85	22.75
Average	16.41	5.35	21.75

Several portions of pork sausage were mixed with 0.2 per cent of sodium sulphite and after standing twenty-four and thirty-six hours were fried in the usual manner and then distilled with phosphoric acid and the sodium sulphite calculated from the sulphurous acid as usual.

TABLE IV.

Weight of meat, 100 g.	After 24 hours	After 36 hours
I	27.72	20.81
II	27.08	20.70
III	28.22	20.28
Average	27.67	20.70

Dr. Calm states in the experiments that he carried out in frying meat "that seventy-six per cent to ninety-six per cent was lost through oxidation." But it is manifestly very unfair to fry the meat, subject it to a long continued boiling with water and phosphoric acid that is necessary in distilling over the sulphurous acid, and assume that the loss was entirely due to the process of frying. In fact it is very probable that the loss due to the oxidation from the boiling during distillation is larger than that due to the process of frying, as in the first case the sulphurous acid is in the free state and more easily oxidized than when in the combined state as in the second case. Table IV shows that very nearly as much sodium sulphite is recovered with the fried sausage as with that which has been subjected to the process of distillation only. It is very evident from a study of Table II that surprisingly large amounts of unoxidized sulphite are liable to be taken into the system. For example from Laboratory Numbers 2635, 2636 and 2651, 0.356 gram, 0.3515 gram and 0.361 gram of sodium sulphite were recovered from 100 grams of meat. 200 grams of sausage would be easily eaten by an ordinary adult at a meal; this would mean an average of at least .7 of a gram of unoxidized sulphite taken into the system in the above instance, along with 2.5 grams approximately of sodium sulphate or "Galuber's Salts," as it is more often termed. This being the oxidation product of the sodium sulphite. Even Dr. Calm himself must concede that a dose like the above would surely produce harmful results.

PART II—ESTIMATION OF COMBINED SULPHUROUS ACID IN DRIED AND EVAPORATED FRUITS.

Fourteen samples of dried or evaporated fruits offered for sale in this state were examined quantitatively for the amount of combined sulphurous acid present. The amount recovered, calculated as sodium sulphite, being given in the following table. Assuming, as in the case of meats, one-fourth was recovered, the amount originally present is indicated in the third column.

TABLE V.

	Amount of fruit used, 100 g.	Amount recovered	Per cent originally present, (estim'd) sodium sulphite
2604	Ruby Prunes	0.0425	0.17
2607	Evaporated Apricots	0.165	0.66
2608	Evaporated Peaches	0.115	0.46
2617	Evaporated Peaches	0.112	0.45
2619	Ruby Prunes	0.190	0.76
2620	Dried Apricots	0.149	0.60
2640	Silver Prunes	0.046	0.18
2653	Silver Prunes	0.086	0.34
2666	Silver Prunes	0.110	0.44
2685	Silver Prunes	0.226	1.00
2730	Ruby Prunes	0.141	0.56
2731	Ruby Prunes	0.174	0.70
2732	Silver Prunes	0.123	0.49
2787	Ruby Prunes	0.054	2.22
	Average	0.124	0.50

The average amount of combined sulphurous acid calculated as sodium sulphite in the above analysis, approximates very closely that found in the embalmed meats and granting that one-fourth was recovered, the amount originally present is sufficient to condemn these fruits at once as an article of diet.

Conclusions:

1. The amount of sulphites mixed with meats to preserve them is much larger than is generally supposed.
2. The amount of sulphites recovered is approximately one-fourth the amount originally present.
3. The amount of unoxidized sulphites in fried meats (sausage) is much larger than several writers would have us to believe.
4. With dried fruits which have been bleached with sulphurous acid free or combined, the amount remaining in the fruit is large, averaging 0.50 per cent. In one instance as much as 1 per cent being found.

NORTH DAKOTA AGRICULTURAL COLLEGE

Government Agricultural

Experiment Station

OF

NORTH DAKOTA.

Bulletin No. 64.

ROOT SYSTEMS OF FIELD CROPS.

By J. H. SHEPPERD.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
March, 1905.

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ROOT SYSTEMS OF FIELD CROPS.

BY J. H. SHEPPERD.

The results herein presented upon a study of the root growth of plants will serve to supplement that given in Bulletins 36 and 43 of this Station. The root growth of several of the crops illustrated herewith has not previously been studied, while the added work upon the kinds which have previously received attention, adds the results of another season and in most cases indicates that the forms and extent of growth recorded for the earlier seasons recur annually. It is possible that a careful study of where our domestic plants penetrate beneath the surface of the ground during the growing season may have a strong bearing upon many problems of moisture, plant food supply and utilization. It is also possible that there are characteristic differences in the root growths of plants which have a bearing upon their adaptation to particular localities.

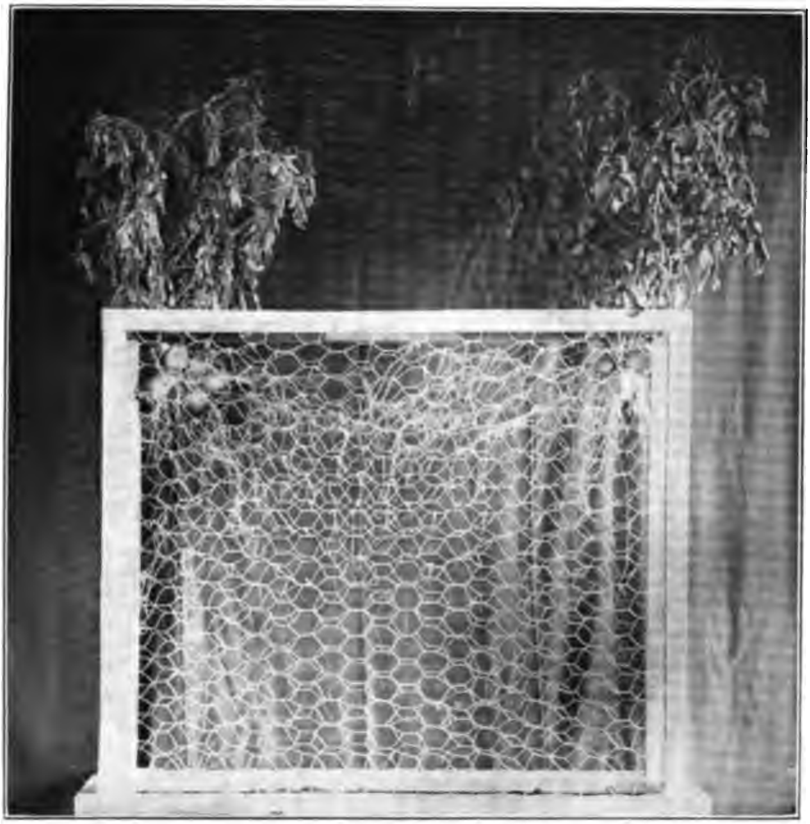
The samples of corn and potato roots really represent little more than the growth sent out by a single hill, as the crate includes only a few inches more than the roots from two half hills that had grown in a ledge of earth twelve inches wide extending from one hill to the other, which ledge was washed away leaving the root fibres. The corn root sample represented by the half tone engraving was taken from a field of twenty-five acres in extent which had been cultivated reasonably shallow with common corn cultivators during the season in the ordinary way. It was of the Golden Dent strain and was fully grown on September third when the sample was washed out.

No special preparation or loosening of the soil or subsoil was made where any of the crop samples grew, they were normal in every way and there can be no basis for doubting that all parts

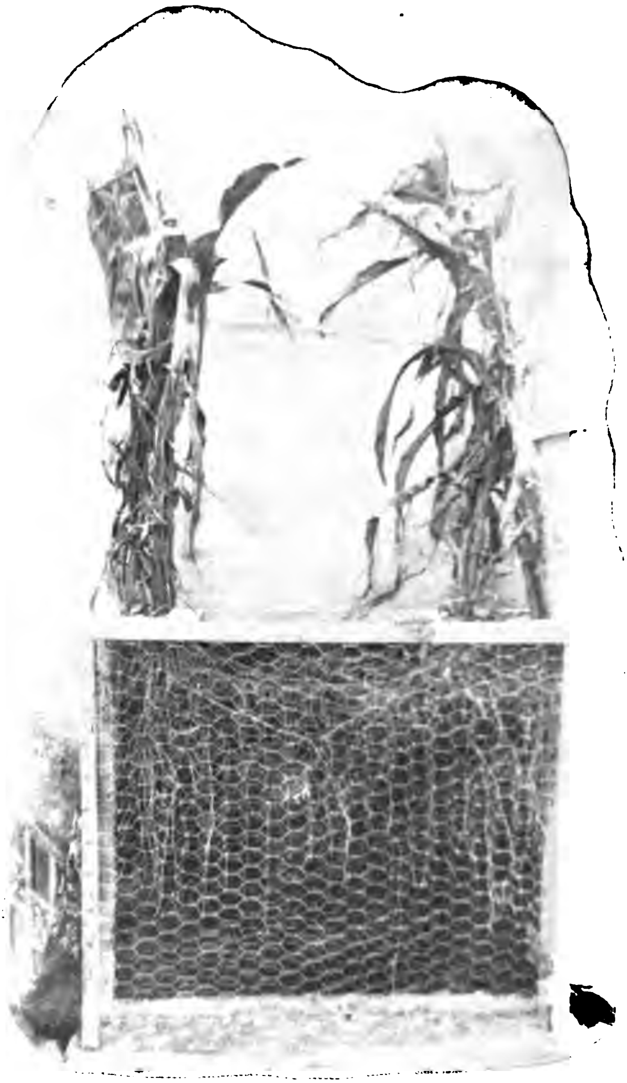
As the illustrations indicate, both the durum or macaroni and bread wheat samples reached the normal depth for this district, of somewhat more than four feet; also that the system of rooting is vertical instead of latteral as is the case with potatoes and corn. It is probable that the crowding which occurs among the cereal roots beneath the surface of the ground induces a direct downward tendency, the same as crowding among stems of plants cause a straight upward growth and for nearly the same reason. Both the durum and bread wheat samples produced a normal root growth from the standpoint of the thickness of the mass of fibres, and while there was little difference in the two specimens, the maraconi growth was the heavier.

The root growth of cereals seems to vary considerably during different years. The season of 1898 produced the heaviest root growth in cereal plants which has been observed at this Station in a study covering five years. The illustration herewith of a sample of wheat roots taken up that season shows the maximum wheat root development thus far discovered by this Station:

The illustration of the roots of barley and oats presented herewith each show a comparatively light and shallow growth. As this cut represents the first specimen of barley roots taken up by this Station, there is no means of determining whether the growth is normal or not, but the studies made during other seasons indicate that these oat roots are only about three-fourths normal length and that the volume of growth is smaller than usual. The crates containing such of the described specimens are twelve by twelve by forty-eight inches in their dimensions, and the samples were taken out as already described for the washing out of corn roots.



Early Ohio Potato Roots, 70 days after planting. From the crop of 1899



Mature Corn Roots, taken upon the Edgeley Sub-station farm strata of shale beneath the surface of the Edgeley farm probably accounts for the shallowness of their growth, as the layer of shale doubtless causes the lower portion of the dirt to be dry and uninviting to plant roots.

These later studies in corn roots emphasize the earlier conclusion that shallow cultivation alone will prevent root laceration.

A sample of potato roots was taken in 1903, and shows about the same development as those illustrated in bulletin 43 of this Station. A photograph was not taken promptly after the roots were washed out, and the sample was injured too much by the time the photographer reached it to make an illustration which would have value. An earlier sample of potato roots taken from the growth of 1899 is presented herewith to give the reader an understanding of the form of growth made by the roots of a potato crop.

The potato root illustration presented herewith shows a slightly heavier supply of shallow surface roots than usual and a lack of deep growing ones as compared with the other specimens taken up by the Station. All of the potato root studies made by the Station indicate that shallow cultivation must be practiced if the roots are to grow undisturbed by the shovels of the cultivator.

The three cereal root specimens illustrated in the cut were taken from the growth of the season of 1903 upon the Station grounds. The taller growing one is winter rye and it was washed out on July 7th. The growth of the roots of this sample reached a depth of only three feet, and while the illustration does not do the sample justice, the supply of roots was lighter than the Station has commonly found for cereals. This sample suggests the question: Do winter cereals root as heavily as the spring varieties? In this northern latitude where the ground freezes deep in the winter it is probable that the soil is too cold at a depth greater than three feet, prior to July 7th, to prove a suitable root zone for cereal plants. By inspecting the illustration, the root growths of spring and winter wheat may be compared.

of the surface of every similar field in the district was similarly filled with crop roots.

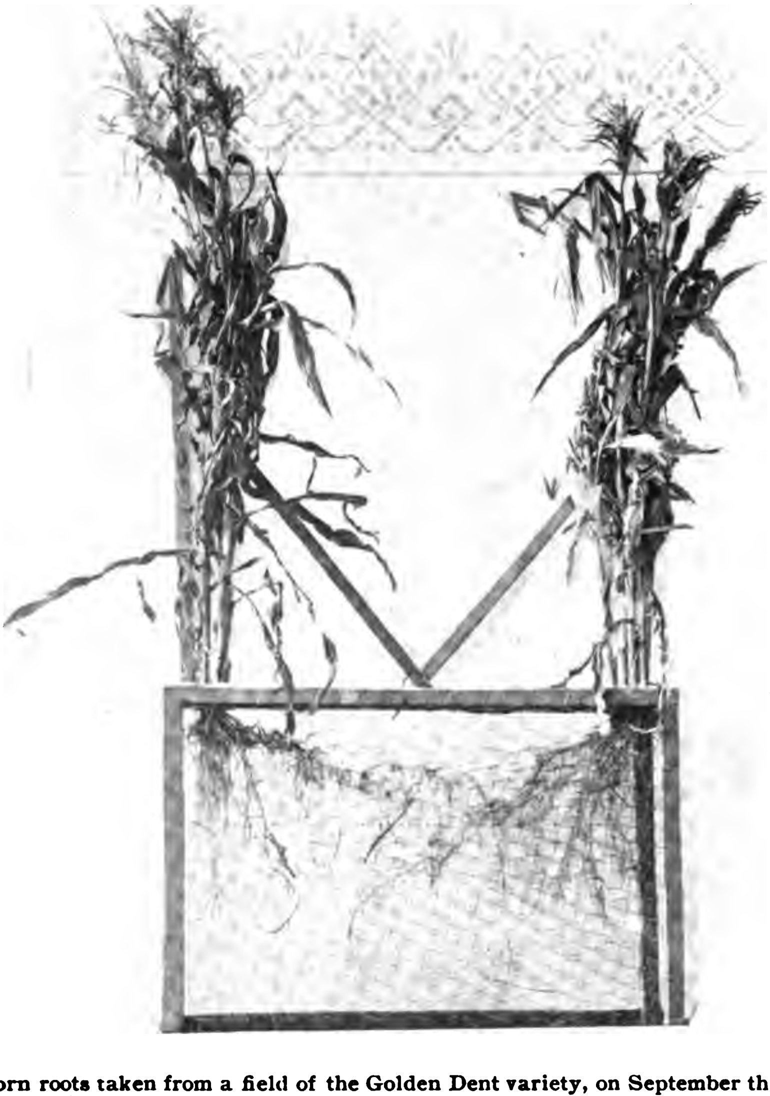
Illustrations of root growth are apt to mislead persons who have not had experience in taking them out of the soil, and attention will be called to a few of the things which may prove confusing.

In taking up a sample of roots a trench is dug about a pillar of dirt in which the roots extend and ramify. The wire cage of poultry netting which shows in the illustrations has neither top nor bottom and it is slipped over the sample of soil, which it should fit closely. Plaster of Paris is then poured upon the top of the dirt until it stands level with the upper edge of the frames. When the plaster of Paris has set, it holds the tops of the plants rigidly in position. Sharpened wire skewers are pushed through the mass of dirt and are allowed to rest upon the mesh forming wires of the poultry netting. A wagon tank load of water is drawn out into the field and a force pump is used to spray the water for washing the dirt away from the roots.

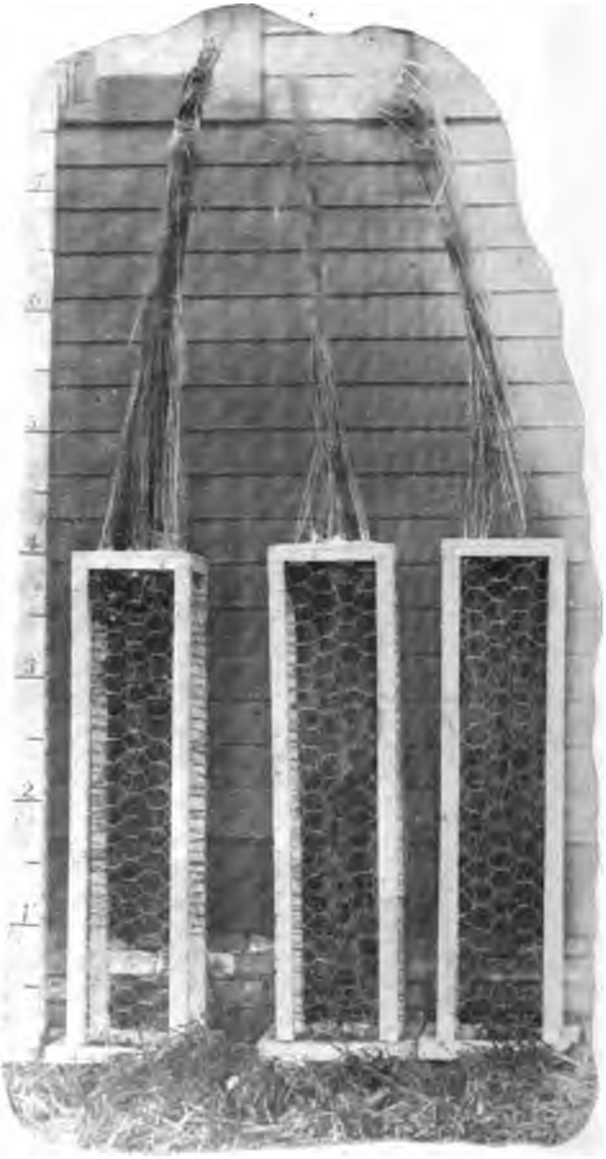
The bottom of the upper rail of the crate frame represents the surface of the ground in which the roots grew. The crate in which the corn roots were taken is three and a half feet high, and inspection of the cut indicates that the roots penetrated the soil to that depth in 1903. Corn roots on the Station ground commonly reach a depth of three and a half to four feet as is shown by root experiments covering a period of five years. Inspection of the illustration shows that the surface roots were further below the top of the ground in the 1903 sample than usual, having a depth of nearly six inches at the middle point between the hills. It also shows that corn annually persists in producing a heavy and extended rooting system.

The samples of corn roots taken in the Edgeley Sub-Station gives the single example which the Station is able to cite of a corn root study made at another place in this state.

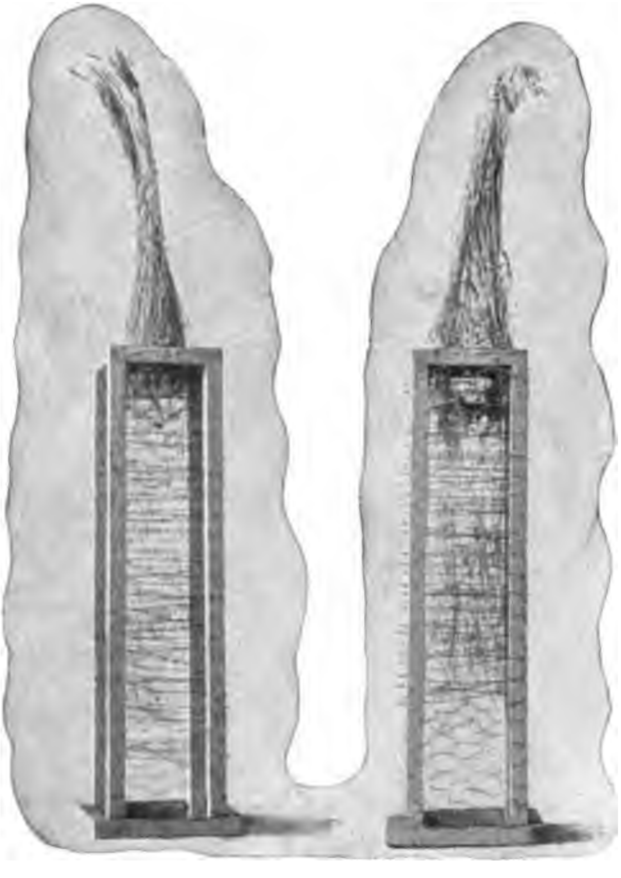
It will be seen that the roots of the Edgeley grown sample did not penetrate so deep as the ones grown at Fargo, although the system of rooting was extended and heavy. An underlying



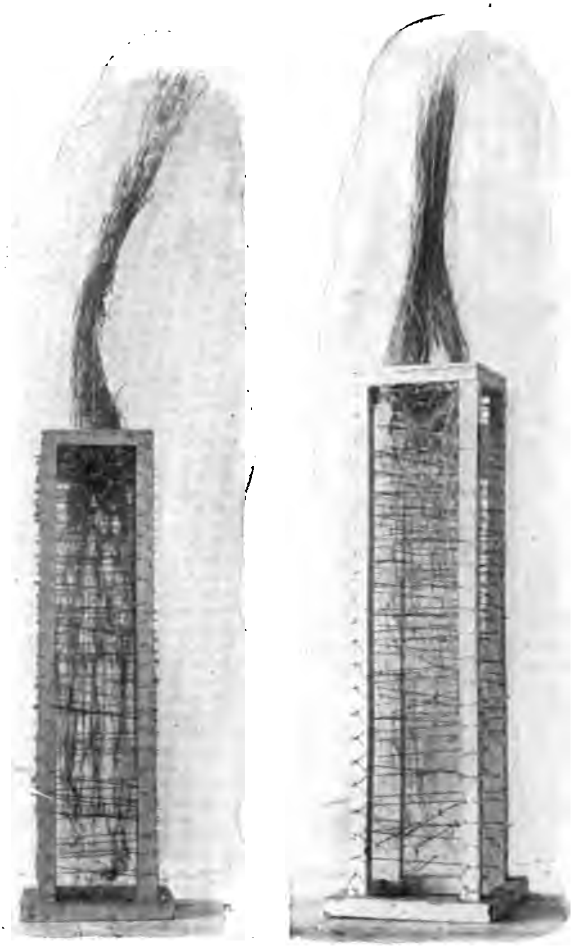
Corn roots taken from a field of the Golden Dent variety, on September third, 1903. The corn was mature, and bore reasonably good ears.



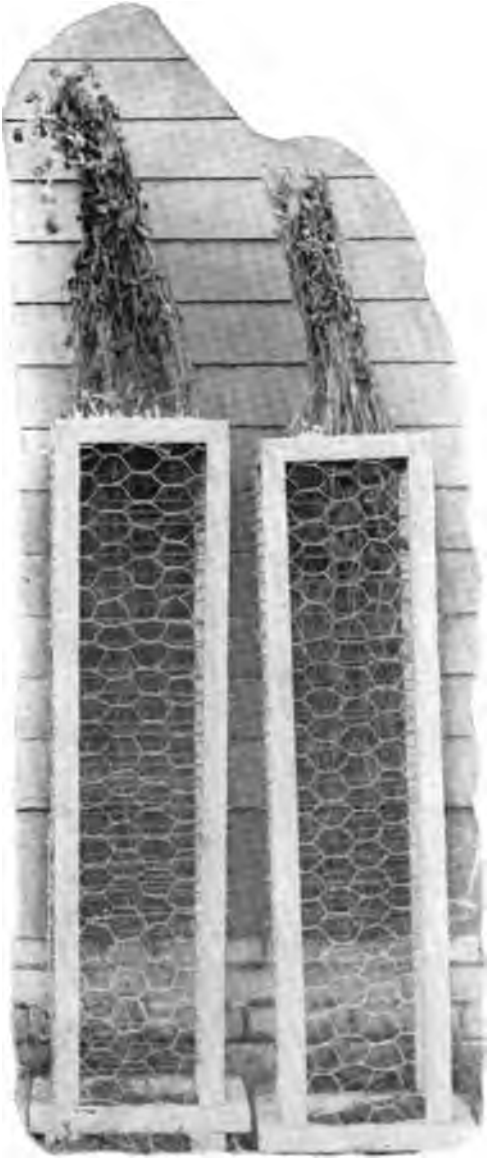
The sample next to the measuring rod is Winter Rye, taken up July 7th, '03. The middle one is Durum, or Macaroni wheat, taken up August 14th, 1903. The third sample is a Fife-Blue-Stem cross-bred wheat, and was taken up August 13th, 1903.



A sample of Barley Roots taken up July 28th, 1903. The sample of Oat Roots was taken up August 6th, 1903.



The root systems of three year old sods of Brome Grass and Slender Wheat Grass. The Brome Grass sample was taken up July 27th, and the Slender Wheat Grass Aug. 3, '03.



Sample of red clover roots from a sod planted in the spring of 1901. The sample of red clover roots were taken up Aug. 25, 1903 and shows the second growth of the season.

The right hand sample is crimson clover roots from the first season of growth. The crimson clover roots were washed out on Aug. 22nd.

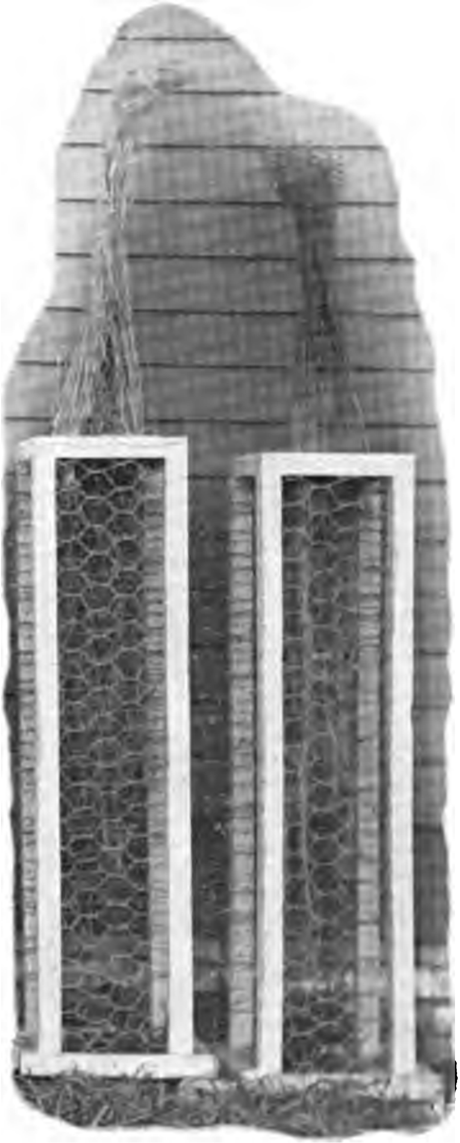
on the right in the cut presented herewith. It has value only in proving a verification of the one already presented.

The picture on the left side of the illustration shows the second top growth of alfalfa for the season of 1903. The alfalfa was from Utah seed sown either in 1900 or in 1899. As the illustration indicates the roots in this sample were not heavy, showing a smaller diameter at the crown than might have been expected. They were taken out to a depth of five feet, but the crate was too shallow to enable the investigators to determine the total depth which they reached. The roots were numerous and strong growing to that depth, as may be noted by consulting the illustration.

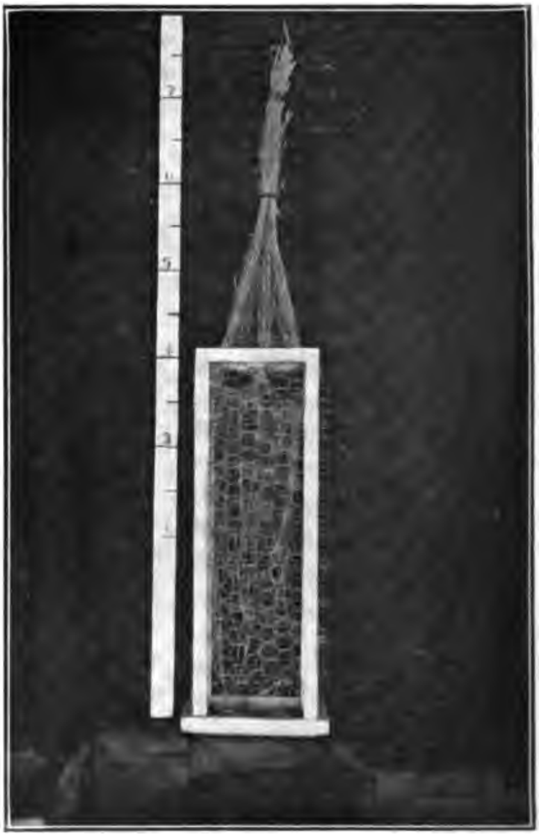
Prof. C. J. Zintheo supervised the work of taking up the series of root samples washed out in the summer of 1903, and rendered the work possible by interesting the Louisiana Purchase Exposition exhibit committee of Cass County in securing the samples, the most of which became their property after the photographs were taken. The Cass County committee referred to, furnished the funds which defrayed the expense of securing the samples.

Mr. Oliver Dynes, a student of the College, had direct charge of the work of taking up the samples from the field, and did all of the spraying to remove the dirt from the roots and cages.

The writer desires to give due and full credit to all of the persons mentioned above for the part which they took in this interesting study.



Sample of Emmer or Spelt Roots taken up August 8th, 1903. Flax Roots taken up August 8, 1903.



Sample of Wheat Roots, taken up at maturity in the season of 1898—110 days after planting.

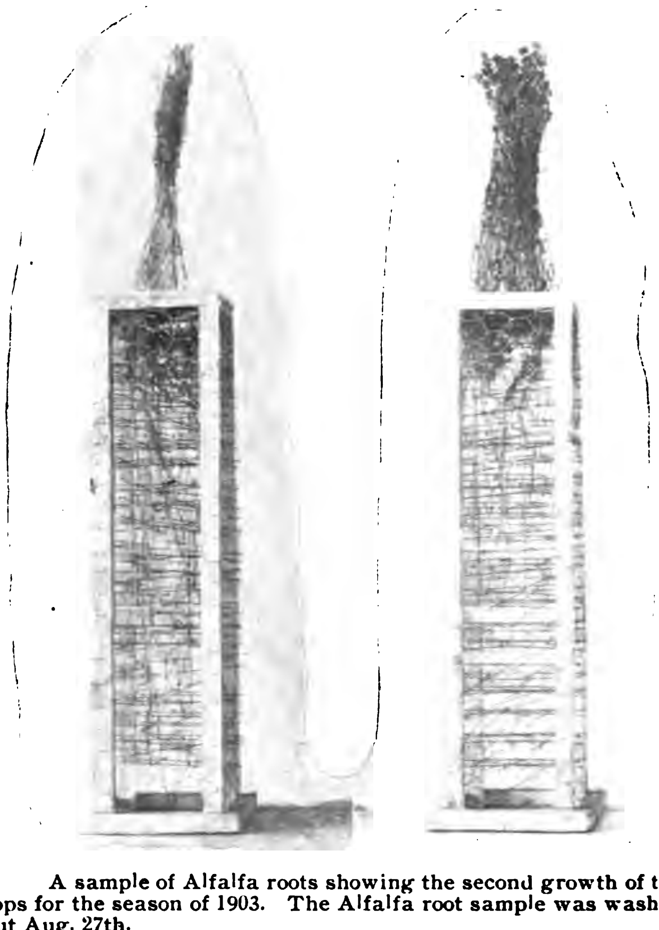
The crate of emmer or spelt roots which appears on the cut with the flax sample is the first specimen of emmer roots taken up by the Station. They are both heavier and longer than the barley and oat roots, studied the same season, as they extend down to a depth of three and one half feet. They show little difference in type from the wheat samples. The flax specimen shows a particularly strong root development as compared with the previous samples studied.

The roots of this specimen of flax had reached a depth of four feet and like the flax plants, examined during previous seasons, they grew almost directly downward and branched very little.

The brome grass picture represents the system of roots developed in a three year old sod. Like the previous samples taken, it sows the most dense rooting system of the entire list of field crops. The native slender wheat grass sample shown beside it is a sod of the same age and shows a strong root growth, but one less heavy than that of the brome grass. Next to brome grass, however, slender wheat grass shows the heaviest system of roots studied.

The red clover root sample shown in the cut submitted herewith represents the growth found in a sample sowed the second spring previous (1901). The tap root form, known as the normal one for clover, is clearly shown in the specimen. The roots had penetrated little beyond the depth of four feet, but they had occupied the upper three feet of soil quite fully. The other sample shown in the same illustration was the growth of a single season and consists almost exclusively of the annual strain known as crimson clover. It is interesting to note that the root system of this annual plant reached a depth of three feet by August 22nd., and that while the ground was fully occupied with roots they were of smaller calibre than were those of the two year old red clover sample illustrated beside it.

A second sample of red clover roots from the two year old plat described above, formed the subject for the root illustration



A sample of Alfalfa roots showing the second growth of the tops for the season of 1903. The Alfalfa root sample was washed out Aug. 27th.

The clover sample was from a two year sod. The clover roots were washed out Aug, 25, 1903.

NORTH DAKOTA AGRICULTURAL COLLEGE

Government Agricultural

Experiment Station

OF

NORTH DAKOTA.

Bulletin No. 65.

EXPERIMENTS IN CLOVER GROWING.
TRIALS WITH ALFALFA.

By J. H. SHEPPERD.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

Fargo, North Dakota, U. S. A.,
April, 1905.

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EXPERIMENTS IN CLOVER GROWING

BY J. H. SHEPPERD.

The clover trials made by this Station have been carried on for twelve years, although accurate yields of hay have been recorded for only seven seasons. The question of hardiness in this climate is the one which concerns the North Dakota crop growers more than any other single feature and it has been the one uppermost in my mind during this study. Some of the less common clovers have been studied in comparison with the medium red strain. The crops grown from the seed of red clover from different states and countries and from that purchased upon the different seed markets have constituted interesting features in the search for hardy strains. The seed used in most of the experiments was purchased from northwestern seed firms. In the trial with clover from different states and countries, the United States Department of Agriculture furnished the seed and aided by their co-operation with the local Station a breeding trial which is still in progress was begun ten years ago with northwestern commercial seed as a foundation stock.

SEEDING CLOVER WITH A GRAIN DRILL.

Seeding grass and clover with a drill or other device which will allow the grower to place the seed at a nearly uniform depth instead of the irregular covering which results from broadcast sowing and harrow covering can scarcely fail to prove advantageous. The harrow covers some seed very deep, leaves some on the surface and distributes the remaining portion at various depths between these two extremes. I believe that an intelligent man can examine a soil and form a reasonable judgment as to the depth which grass seed should be planted, and I believe the drill is the best devised machine for planting seed at a desired depth. A special and separate drill for seeding grass crops will scarcely be cheap enough to prove a practical implement in North Dakota for many years to come and therefore the grain drill must be made to serve both purposes. Grass seed put in with a drill across the rows of grain gives the young grass plants full possession of the soil and sunlight in the interspace between the drill rows until such time as the grain is six or eight inches high. The factors mentioned above must prove a strong advantage to the young grass plants over a method of seeding which places the grass seeds in the drill row where they must compete with these larger stronger plants for moisture, sunlight and plant food.

In the spring of 1895 a trial in growing timothy and clover seed with a grain drill was commenced. An eighty acre field was sown to wheat with the drill rows of grain running north and south. The grass seed was then put in with an ordinary shoe chain grain drill which was driven east and west, or across the wheat drills. The drill was allowed to run very shallow—an inch and a half to two inches deep—while seeding the grass. To regulate the rate of sowing, common barrel salt was used and proved very satisfactory. The mixture as sown was eight pounds of timothy seed, five pounds of red clover seed and four pounds of common barrel salt per acre. After a short time the grass plants appeared in the cross drills in such a thrifty growth that the drill rows could be traced by the eye at some distance. The growth of wheat was heavy yielding, over twenty bushels of No. 1 Hard grain per acre, and the stands of grass was excellent. This eighty acre field produced an average of a ton and a quarter of hay per acre the next season after the clover was seeded.

In 1896 a twenty acre field was sown with barley and cross drilled with the timothy, red clover, and barrel salt mixture described above. The grass came on well and made an unusually fine stand.

In 1897 timothy and red clover were again put in with a common grain drill and barley was used as a nurse crop. The grass was cross drilled after the barley was sown—in the manner described for the previous season. Instead of using salt to mix with the grass seed, coarsely ground barley was substituted. To prevent the wind from blowing the seed away, after it had been thrown out by the force feed and before it dropped into the hose, a wind break of canvass about eight inches high was placed around the frame of the drill just back of the force feed. The drill did excellent work with the ground barley and grass seed mixture. The change from common barrel salt was experimented upon by reason of a failure of the salt to become damp and stick to the grass seed as it had done during the previous two seasons. The air had probably been much more moist and humid when the seeding took place during the seasons of 1895 and 1896 than it was in 1897. The plan of seeding clover and a mixture of clover and

Lawn on College Campus. Blue grass, red top and white clover
Photograph taken six weeks after seeding.

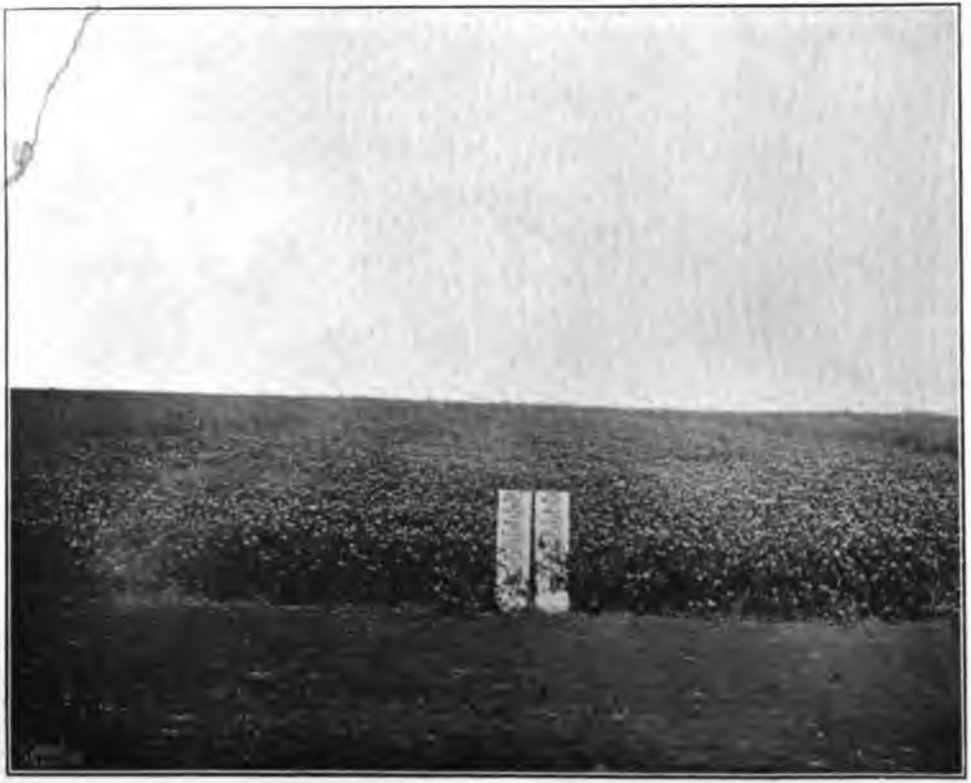


Photo of Medium Red Clover, grown on the Station rotation plat in 1902.

timothy seed with a grain drill has many advantages over sowing it broadcast, and the trials made at this Station indicate that it gives a considerably greater degree of assurance that a "catch" of grass will be secured than the broadcasting method does.

SEEDING CLOVER ALONE AND WITH A NURSE CROP—THE EFFECT OF WINTER SEASONS UPON THE CROP.

Trials have been made in seeding red clover with a nurse crop and alone. With few exceptions a "catch" has resulted from each method, but the clover seeded with a wheat crop usually withstands the following winter better than that which does not have the snow holding protection of grain stubble during the winter season.

With a single exception during a nine year's trial, medium red clover seeded with a nurse crop has passed through the first winter without killing out. The second growth of red clover has been allowed to stand as a snow holding protection in the trials made with it. By allowing the second growth of clover to stand after maturing, a considerable quantity of fresh clover seed falls upon the land each year. I have observed that a great many clover plants spring up from this new seed, forming a reinforcement to the stand of clover in the field.

The plan of allowing the second growth of clover to stand, preserves the crop from winter killing about one half of the time. It has been very rare for all of the clover plants in a field upon the Station grounds to winter kill and it is very common for volunteer plants to spring up for two or three seasons after the crop has been plowed under. During about one half of the winter seasons clover plants which were more than a year old have winter killed below the degree of thickness recognized as a stand. The young crop of clover has proven stalwart enough to withstand the rigors of nearly every winter when provided with the protection which the average stubble field provides.

The field trials made at this Station indicate that the practical plan to follow in clover growing for this district is to seed it with a nurse crop of small grain (preferably wheat), take a single hay crop from it and plow it under after the hay has been removed.

I have carefully inspected the fields of grass and clover upon the Station grounds and College fields after each of the past eleven winter seasons and I have not found a single case of clover or grass plants having been heaved or lifted by frost. Grass, clovers of the different sorts and alfalfa plants are frequently destroyed by having a shallow coating of ice over them during the winter season. My attention was first attracted to this point by having seen the distinct and clear cut outlines of dead blue grass and white clover where a skating rink had been located the previous winter. On another occasion a winter road was formed across trial plats of grasses, clovers and alfalfa. The teaming packed the snow into ice the width of the sled tracks and while the road was abandoned before the snow and ice melted away the opening of spring showed the medium red, mammoth, alsyke and white clovers together with alfalfa, timothy and red top dead where the ice had formed and in prime condition upon all other portions of the plats. Brome grass and the weed quack grass alone withstood the adverse covering of the ice sheet.

THICKNESS OF SOWING—CLOVER MIXED WITH TIMOTHY VS. SEEDING CLOVER ALONE—TRIAL WITH SEED FROM DIFFERENT SOURCES.

No specific trial has been made with different quantities of seed but satisfactory stands have been secured by seeding it at the rate of fifteen pounds of clover seed per acre. A mixture of five pounds of red clover seed and eight pounds of timothy has given a mixture of from a half to three-fourth of timothy plants in the resulting growth, the thickness varying with the season.

A mixture of ten pounds of Mammoth clover with four pounds of timothy seed has given an average proportion of more than three fourths clover in the hay. This trial, was made upon a twenty acre field. A trial covering a period of four years in growing clover alone, compared with a mixed crop of timothy and medium red clover under similar conditions gave the following results:

Average yield of hay per acre for four years from a mixed crop of timothy and clover	3,356 lbs.
Average yield of hay per acre for four years from clover alone	3,265 lbs.
Difference	91 lbs.

From this trial it will be seen that the difference in hay yield from medium red clover and from a mixed crop of clover and timothy is small, and the slight difference shown is in favor of the mixed crop. Had the second growth of clover been saved for hay the total yields would have made a much larger showing in favor of the pure clover in point of yield.

SEED FORMING CAPACITY OF NORTH DAKOTA GROWN RED CLOVER.

Red clover grown in this district seems to fill well and the first growth bears more seed than I have been accustomed to see it do in Iowa and Illinois. Clover produced from southern grown seed and that from most of the foreign sources of supply proved poor seed producers here. In nearly every instance these clovers have produced about the normal number of seeds but the seed was so poorly filled that it was worthless. In a few instances the seed from the second growth of foreign and southern grown seed was quite green at the time killing frost occurred in the field.

These plats of clover show very little variation in the time that the blossoms of the first growth of plants appeared.

CLOVER BREEDING—YIELDS OF RED CLOVER.

The freedom from hairness of many of the foreign clovers indicates that American breeders can reduce the dustiness of their clover hay by breeding a smooth stemmed strain.

The Station now has a peck of red clover seed as the crop of 1904 from plants which sprang from an ancestry that has lived upon an open field for ten years.

Ten trials with red clover alone and with red clover and timothy grown as a mixed hay crop, covering a period of six years, gave the results recorded below. The trial was running during the season of 1900 but as all hay plants failed to produce a crop that year no record is entered for that season.

The following table gives the detailed results for the trial:

YIELD OF HAY FROM CLOVER AND FROM CLOVER AND TIMOTHY. GROWN AS A MIXED HAY CROP.

	Yield per acre.
Red Clover crop of 1893	2,070 lbs.
Red Clover crop of 1894	3,225 lbs.
Red Clover crop of 1896	2,275 lbs.
Red Clover crop of 1903	3,659 lbs.
Mixed crop red clover and timothy 1893	1,715 lbs.
Mixed crop red clover and timothy 1894	3,000 lbs.

Mixed crop Mammoth clover and timothy 1895	5,000 lbs.
Mixed crop red clover and timothy 1899	4,731 lbs.
Mixed crop red clover and timothy 1903	3,615 lbs.
Average yield of hay for ten trials	3,376 lbs.

In the trials reported above the second growth was not harvested and hence is not included in giving the hay yield although in most instances it made a reasonably heavy second growth. The average yield of a little more than a ton and two-thirds of hay as a crop, can scarcely be considered a discouraging result. I am of the opinion that, where a hay crop is grown for its rotation effect upon grain land in the Red River Valley and similar portion of the state, that a mixed crop of timothy and clover is as economic a production as can be found.

MAMMOTH CLOVER TRIALS.

Trials with Mammoth and Alsyke varieties of clover at this Station have been interfered with by flooding and partial snow covering until the results in yields of hay are not fully comparable for many of the seasons. The plats have been subjected to careful observation each season and their condition and degree of promise have been carefully recorded. As a result I feel able to give a much more definite statement relative to them than the yield data alone would warrant.

Fewer trials have been made with Mammoth clover than with the medium red variety. Its habit of not sending up a second growth of stems has seemed to me to be seriously against it as that growth causes a lodgment of snow which protects the crop during the winter season. Mammoth clover grows larger and coarser than the medium red variety and on that account lodges worse and forms coarser, less palatable hay. The yields recorded for Mammoth clover are as follows:

YIELD OF HAY FROM MAMMOTH CLOVER.

	Per acre.
Mammoth Clover Hay, 1895	5,000 lbs.
Mammoth Clover Hay, 1896	2,270 lbs.
Average yield per acre	3,635 lbs.

The crop of Mammoth clover which made the heavy yield in 1895 killed out almost entirely during the following winter while the medium red variety under similar conditions was not severely injured. The Mammoth variety of clover has shown itself inferior to the medium red or common red sort for this district.

ALSYKE CLOVER TRIALS.

Alsyke clover has been grown upon the trial grounds of the Station beside the Mammoth and medium red varieties for a number of seasons. It has been subjected to close scrutiny and the observations have been carefully recorded. Alsyke has withstood the winter seasons better than the mammoth variety. It is a finer stemmed clover than the medium red kind and makes hay of fully as good a grade. It has made a better showing than mammoth clover and has yielded somewhat less than the medium red variety. In a trial upon wet ground it showed an especial adaptation to such land and gave better results than the other varieties under moist conditions. The pink shade of color in the blossoms of the alsyke clover together with its shorter stems makes it easy to identify.

WHITE CLOVER.

White clover is very hardy in this district, but it grows too short and creeping to form a hay plant and is too easily dried down to form as good a pasture plant as it does in districts which have a heavier annual rain fall. White clover causes horses to "slobber" during times when the seed is forming and it is especially undesirable in horse pastures on that account. It is prolific and reasonably satisfactory lawn plant and grows luxuriently when intermingled with blue grass upon lawns which can be sprinkled or irrigated. Both white clover and blue grass are short rooted plants and require regular and frequent watering to prevent them from drying out and turning brown.

BERSEEM.

Berseem has been grown in a small way on the Station grounds, but the trial with it has not been extended enough to warrant a conclusion as yet. It does not give promise of proving superior to medium red clover although definite statements are withheld until a future date. Berseem can readily be identified, for while it bears stems and heads like those of medium red clover in shape and size, its blossoms are white in color.

SWEET CLOVER.

Sweet clover is commonly listed as a weed and has not been considered valuable except as a honey plant for bees. There are two sorts of it known as white and yellow, according to their blossoms. The odor and flavor of sweet clover are distasteful to live stock, both in the green form and as hay, so that it is useless as a forage plant.

CLOVER BACTERIA.

That nitrifying bacteria are essential to the growth of clover in nearly every soil has been demonstrated beyond all question. When these bacteria are present, tubercles or wart like nodules will be found upon the roots of clover plants. An examination of the roots of growing clover will enable any one to tell whether the ground is supplied with this class of bacteria or not.

There is no easy way to determine whether they are present or not except by observing whether the plants bear tubercles or not. If there is a lack of these nitrifying bacteria in the soil, they should be added either by strewing infected soil from an old clover patch over the field or by applying bacteria from pure cultures, such as are being sent out by the Bureau of Plant Industry of the United States Department of Agriculture, at the present time.

ALFALFA.

Extensive trials with the two hardy strains of alfalfa seed have constituted an important part of the field trial work of this Station during the past four years. During the six seasons prior to that time experiments with the common or commercial strains of alfalfa seed gave evidence that they were not adapted to the conditions which prevailed in this state.

The records which follow indicate the degree of promise which these hardy strains have given. The crop producers of North Dakota should not give up hope in the ultimate success of this valuable crop even if the Turkestan and Grimm sorts do not prove a full success, as the plant breeding work of the Station is slowly developing strains of alfalfa which give promise of proving much more hardy than either the Turkestan or Grimm varieties.

Trials are now in progress at the central Station at Fargo and at the Edgeley Sub-station in sprinkling bacteria infected soil from old alfalfa regions upon our trial plats, and that feature of the study will be extended in the future if the trials give the results which they now promise.

The results at this Station indicate that alfalfa should be sown without a nurse crop upon well prepared land and at the rate of fifteen pounds of seed per acre. The Station has been able to secure good results from seeding it broadcast and covering it by a double harrowing with a peg tooth harrow. Weeds often spring up heavily during the first season and they should be cut with a mower occasionally to keep them from smothering the young alfalfa plants and to keep them from ripening seed. In mowing the weeds, set the sickle bar high enough so that the ground will not be left too bare and the young alfalfa plants too badly crippled.

TURKESTAN ALFALFA TRIALS.

The following summary of the trials with Turkestan alfalfa during the past three seasons will complete the evidence which the Station has recorded relative to that crop. The following from the Twelfth Annual Report gives the details of the first year's experience with it.

RESULTS IN 1901.

"A plat of two and one-third acres in extent was sowed to Turkestan alfalfa on May 21, 1901, at the rate of fifteen pounds per acre. The seed used was purchased from Currie Bros., seedsmen. The seed was sown broadcast upon the land which had been in a timothy and clover meadow for several years. This plat had been broken the fall before, and was in good tilth, which permitted the seed to be harrowed in reasonably well. On July 2, twelve days after sowing, the young plants stood two inches high, constituting a good stand. Later in the season the plants growing in small groups from two to ten feet across, and irregular in form took on a yellowish hue and failed to grow as rapidly as their neighbors. That condition was probably caused by the water standing upon the spots so affected—shorter or longer periods—during the growing season."

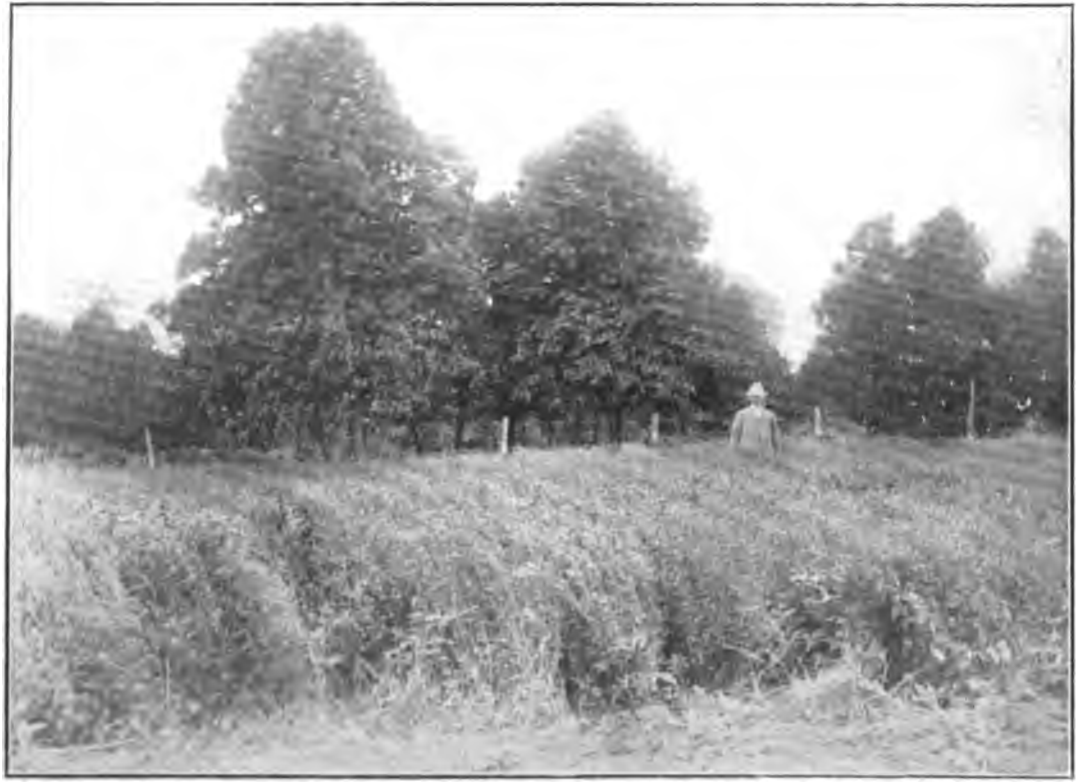
"On August 2nd, the plat had a fair crop of hay upon it, but is was somewhat weedy in some places with pigeon grass or foxtail, and amaranthus or red root. The alfalfa was twenty to twenty-two inches high except in the yellow groups where the crop had only a height of from six to ten inches. A few of the plants were showing blossoms upon the above dates."

RESULTS IN 1902.

The following from the Thirteenth Annual Report gives the outcome of the trial in 1902:

"The two and one-third acre plat of land—reported upon in the Twelfth Annual Report of the Station, page 47—made a good growth in 1902, and showed no signs of winter killing. The leaves of the plants were severely attacked by a rust which caused them to drop off badly. The crop was cut for hay during the first week

Mammoth Clover Crop, College Farm. A 20-acre field in 1895.



First growth of Turkestan Alfalfa, grown upon Maj. Darling's Farm near Fargo in 1904.

of july and made a yield of 2,729 pound per acre. .... The second growth came on vigorously and was allowed to stand until the plants were killed by frost to determine whether the seed which had formed would ripen. The seed failed to ripen and the frost caused a heavy loss of the leaves and finer portions of the stems in the second crop, which made a yield of only 1,189 pounds of hay. The total yield of the plat per acre is 3,918 pounds or practically two tons (per acre)..................... "An adjoining piece of the land was seeded to Turkestan alfalfa in the spring of 1902 on summer fallowed land and without a nurse crop. .... The stand and condition of the plat was similar to that recorded for the one sown in 1901, except that very few yellowish colored areas of the plants appeared in the plat."

RESULTS IN 1903.

"The Turkestan strain of alfalfa, seeded in 1901.......... failed to pass the winter of 1902 and 1903 successfully, having been badly winter killed. It was given the most trying conditions by having all of its stem growth mowed close to the ground just before the cold weather of fall began."

"A second plat of Turkestan alfalfa, seeded in the spring of 1902, which was left a growth of stems a few inches high, killed but little during the winter." The results in yield of hay per acre for 1903 were accidentally lost but field notes upon the growth would indicate that a yield of about two tons of hay per acre would represent the returns from the plat.

RESULTS IN 1904.

The plat of Turkestan alfalfa seeded in 1901 had recovered sufficiently to form a reasonably good stand in 1904.

On June 21st, the date of mowing the first crop of hay, the plants measured thirty inches high on the average, and formed a fine appearing growth. The yield of hay from the first mowing was at the rate of 3,600 pounds per acre.

Extremely dry weather hindered the second growth of alfalfa from coming on well. At the date of the second cutting—July 27th—the crop measured twenty inches in height and the yield of hay was 1,000 pounds per acre, making the total yield for the season—from this 1901 sown piece—4,600 pounds of hay per acre.

The plat of alfalfa seeded in 1902 had a stronger and more dense growth and made coarser hay. There is a small percentage of volunteer brome grass in this plat which sprang from a former seeding to that plant, the sod of which had not been entirely destroyed when the alfalfa was sown. The heavy growth of alfalfa seems to be gradually smothering the brome grass out, and as the latter is not plentiful enough to be an appreciable source of error in determining the yield of alfalfa, the contest for supremacy is adding to the interest of the study without vitiating the results secured from the yields of hay.

This plat of alfalfa was cut for hay on June 21st and gave a yield of 4,200 pounds per acre. The second growth which was interfered with by the dry weather already mentioned made a yield of 1,880 pounds per acre.

GRIMM ALFALFA TRIALS.

The Annual Report for the Station field crop work of 1902 contains the following statement relative to the Grimm alfalfa trial: "Seed of a strain of alfalfa, named Grimm by the Minnesota Experiment Station, was seeded upon a plat of land last spring. The growth of the plants came on more quickly and they seemed somewhat more sturdy than those from the Turkestan seed."

REPORT FOR 1903.

The results of the alfalfa yields for 1903 were accidently lost, but the following statement taken from the Annual Report upon the field trial work that year indicates that the yield of hay was probably a litle over two tons per acre: "The Grimm strain of alfalfa, which was sown in 1902 upon ground adjoining the Turkestan trial, has proved more thrifty and vigorous than the Turkestan strain. The Grimm alfalfa filled its seed pods with plump, ripe seeds somewhat better than the Turkestan variety, while the plants descended from Utah seed yielded an abundance of shriveled and emaciated seed which had little growing strength.

RESULTS IN 1904.

The Grimm alfalfa plat showed a thick strong stand in 1904, although it did not grow as high as the Turkestan variety. On June 21st, the date of cutting the first crop for hay, it measured twenty-four inches high. The yield of hay from the first cutting was 3,720 pounds per acre. The second growth was left to ripen and was cut for seed with a binder about ten days after it had been killed by frost. This second growth did not mature sufficiently and the trial indicates that the first crop would have made a better yield of seed than was secured from the second growth. The yield of seed from this second growth was only fifty pounds per acre, about half of which is too immature to grow.

The summarized results of the Station's alfalfa trials expressed in the yields of hay per acre are as follows:

YIELD OF TURKESTAN ALFALFA HAY PER ACRE.

PLAT SEEDED IN 1901.		PLAT SEEDED IN 1902.	
Yield in 1902—			
First cutting	2,729 lbs.		
Second cutting ...	1,189 lbs.		
Total	3,918 lbs.		
Estimated yield in 1903—		Estimated yield in 1903—	
Total	4,000 lbs.	Total	4,000 lbs.
Yield in 1904—		Yield in 1904—	
First cutting	3,600 lbs.	First cutting	4,200 lbs.
Second cutting . ..	1,000 lbs.	Second cutting .. .	1,880 lbs.
Total	4,600 lbs.	Total	6,080 lbs.
Average yield of hay per acre—		Average yield of hay per acre—	
3 years	4,172 lbs.	2 years	5,040 lbs.

The Grimm alfalfa has given a stronger average growth than the Turkestan strain, but owing to the additional promise which it has given as a hay producing variety the absolute yield per seed producing capacity of this strain.

The trials with alfalfa made by the Station, indicate that it may ultimately prove a successful crop in this state. The present scarcity and consequent hig price of hardy strains of seed, the apparent lack of adaptation of the common commercial varieties to this district, together with the probable lack of root tubercle bacteria in many places, seem to warrant the statement that the people of North Dakota should try alfalfa in a small inexpensive way until they have further evidence that it will give certain success in their districts of country. Another advantage of trying it in a small way is, that it will enable them to learn how to seed and handle the crop successfully.

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Government Agricultural

Experiment Station

OF

NORTH DAKOTA.

Bulletin No. 66.

WATERS OF NORTH DAKOTA.

By E. F. LADD.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
August, 1905.

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WATER FOR DOMESTIC PURPOSES IN NORTH DAKOTA.

BY E. F. LADD.

There has been a growing demand, in this state, on the part of the farmers as well as of citizens in general for an examination of waters with reference to their fitness for domestic purposes. During the past year this demand has increased and it is not easy to understand on what ground a matter of such vital importance to the people of the state and their health can be ignored even though there are other lines of investigational work, of great importance to be conducted in agriculture. The examination of doubtful waters by the Station certainly meets an important public demand; and to fail to make these examinations would, in many instances, result in injury to the health of the people of the state as well as of their domestic animals. It has seemed, therefore, wise and proper that this line of work be continued at least until some other provision is made for it.

The waters of this state are found to be variable in composition. Wells, but a few hundred feet apart, not infrequently furnish waters of entirely different natures. On the other hand, waters from the artesian wells are generally more uniform in composition, but even here there are variations between the waters from a shallow artesian well and those from a deep well. Again, there is in the state a restricted artesian basin where the total solids are from five to ten times that of other portions of the state.

In previous reports, I have called attention to the excessive amount of mineral matter in many samples of water which have been sent in for chemical examination.

Complaints of frequent attacks of colic among horses in certain localities and upon certain farms have been repeatedly shown to be due, in large measure, to the character of the water which the animals were obliged to drink. In a few instances it is believed that the death of animals has been due to the continued drinking of waters heavily charged with mineral salts. There have been several complaints of kidney trouble in families where these waters, heavily charged, have been used for drinking purposes. It is, therefore, important that information be furnished to the parties interested in order to protect their health. Such information, at the present time, can only be had from the Experiment Station.

The question is frequently asked: "What is a pure water, suitable for drinking purposes?" or "What are we to understand from the result of the analysis submitted?" The analytical chemist is not, however, especially concerned directly with the question as to the presence or absence of disease germs and this phase of the question is left to the consideration of the bacteriologist. But the solids and organic matter are here more fully considered. The constituents to be examined for, in general, may be divided into two classes: organic products and mineral matter.

ORGANIC MATTER.

A careful examination of the character of the organic matter frequently helps to throw light upon the likelihood of such water being contaminated especially with sewerage and other waste products which might make the water a possible source of typhoid fever infection. The organic matter in water may be from four sources:

First, From surface water washing down decaying matter from leaves, plants, etc.

Second, From water, especially in deep wells, passing through an underground bed of organic matter, such as a coal seam or a body of peat, which is apparently true of nearly all artesian waters in North Dakota.

Third, Organic matter from sewerage.

Fourth, Organic matter derived from the growth of small forms of water plants; algae, etc., that give off some organic matter.

Surface wells in North Dakota contain some organic matter from the first cause mentioned. The artesian waters of the state have considerable organic matter, sometimes as much as 1.5 parts of free ammonia per million; and while this is objectionable, need not be considered harmful unless there is present also considerable albuminoid ammonia. Shallow wells that are situated so as to receive the drainage from the privy vaults, from the barnyard, or the waste slops from the kitchen frequently contain sewerage products, and the water from wells so located is always unsafe and to be condemned at all times.

Dr. Leeds proposes the following as the standard or purity for city supplies in America:

Free ammonia	0.12 parts per million.
Albuminoid ammonia	0.28 parts per million.

Others would place the maximum at not to exceed one-half the above amounts. The presence of albuminoid and free ammonia indicate putrefying organic matter, and this furnishes a good medium for the growth of disease germs, should they find their way into the water; and again, so much putrefying matter, either animal or vegetable, might aggravate or even produce cases of diarrhœa.

In discussing the question of organic matter in waters, Mason sums up as follows:

"The organic matter in suspension decays in about seven days, as is shown by the increase in free ammonia. In about fourteen days this free ammonia has disappeared and nitrite has taken its place reaching a maximum in about twenty days. Later, the nitrite also disappears and in twenty-eight days or more all the nitrogen has been converted into the form of nitrate." Therefore, it is frequently important in doubtful cases to make an examination for albuminoid and free ammonia as well as for nitrite and nitrates. In this state, people are more particularly concerned in the character of the solids, especially is this true in the country districts.

Recent pollution is generally indicated by high free ammonia and low nitrates. Two samples of water from Mayville, one the melted ice and the other taken from the river, illustrate well the condition here indicated.

ANALYSIS OF WATERS.

	Parts per million.	
	Goose River	Ice water.
Volatile matter	502.	18.
Solids non-volatile	1428.	24.
Total solids	1930.	42.
Chlorine	145.	4.
Albuminoid ammonia	0.106.	.099
Free ammonia	0.214	.04
Nitrites	0.0216	none
Nitrates	trace	trace

From the above it will be seen that the ice water is particularly pure; but the river water shows recent contamination, as indicated by the presence of free and albuminoid ammonia and nitrites with an absence of nitrates, while the high chlorine content indicates sewerage, probably animal excreta from stock watered at the river.

As further examples of water badly contaminated we cite the following cases recently examined in this laboratory:

Address	Name	PARTS PER MILLION					
		Free Ammonia	Albuminoid Ammonia	Nitrogen as Nitrites	Nitrogen as Nitrates	Chlorine	Total Solids
Orr	H. B Nelson	.72	37	.043	5 55	50	725
Orr	J D. Nelson	1.45	96	.014	8.33	54	758
Michigan	T. J. Moran	.965	.026	.018	.262	......	2520
Oakes	W. J. Brown	Undetermined	Undetermined	.023	25 60	310	1690
Langdon	H. D. Allert	Undetermined	Undetermined	032	19.51	198	1637

TOTAL SOLIDS IN WATER.

How much solids may a water contain to be safe for drinking purposes? That will probably depend upon the nature of the solids present. Common salt would probably be less harmful than an equal amount of Epsom or Glaubers salts or of sodium carbonate. Again, frequently the condition of the individual is the important consideration; and waters which in health might have been drunk without serious injury become a menace to health when weakened by illness.

In judging of the amount of solids which water may safely contain we may first notice what the total solids amount to in waters which are being furnished to our cities where a fair degree of purity is maintained. In this connection in Bulletin No. 32 I stated as follows:

Wanklyn, the English authority, regards 575 parts total solids per million as permissable. Dr. Smart, formerly of the National Board of Health, says that a safe limit is 300 parts, but that 1,000 parts should condemn the water. It will help us to understand what a pure water is to see what the total solids are in the water supplied to American cities where a fair degree of purity is maintained. The total solids in the water supplied to several cities, expressed in parts per million, are for Boston 47, Philadelphia 134, New York 82, Washington 165, Brooklyn 64, New Orleans 340, Indianapolis 290, and Minneapolis 186. From the foregoing it will be seen that in practice waters are supplied to cities with less than three hundreds parts per million of total solids.

The salts in excess of the amount required for the wants of the body must be again eliminated. This work is largely done by the kidneys; and, when excessive amounts of salts are present, it seems that these organs may become overworked, and disease result. The condition of the individual probably should be taken into consideration, and what may prove harmless in one case might in another less vigorous person result seriously. Again, it would seem that when the salts present are largely Epsom or Glaubers salts and sodium carbonate, there may be serious disturbance of the digestive functions, and even attacks of colic. Waters, then, that contain not to exceed three hundred parts of solids per million are to be desired and above 500 or 600 become questionable as a source of city supply.

Bergey in his work on water analysis discusses this subject somewhat fully and states his views as the result of research in the following manner.

	Solids per million.
Waters to be classed as pure	70
Waters to be classed as useable	430
Waters to be classed as suspicious	430-710
Waters to be classed as impure	710 and upwards

The above classification may be used as a very good guide in the judging of waters for city supply where all classes and conditions of persons have to be met.

Parkes in his Practical Hygiene has the following regarding the influence of certain mineral salts in drinking water:

"Waters with permanent hardness exceeding 7 or 8 degrees often cause dyspeptic symptoms and diarrhœa, especially amongst those who are not used to them. The chlorides, sulfates, and nitrates of calcium or magnesium are the injurious salts. Similar symptoms are generally produced by drinking brackish water drawn from wells near the sea coast. Such water contains a large excess of chlorides of sodium, calcium, and magnesium.

Waters containing calcium carbonate in solution—the temporarily hard waters—are not in any way injurious to health."

In the following table we give, in part, the results of the chemical examination of a large number of waters, coming from all parts of the state. The sanitary analysis for free-ammonia, albuminoid-ammonia, nitrites and nitrates are not shown in this table.

Laboratory No.	TOWN	NAME	KIND OF WELL	PARTS PER MILLION				QUANTITATIVE TESTS				
				Volatile Solids	Non-Volatile Solids	Total Solids	Chlorides Salt	Carbonates C O	Sulphates S 03	Lime Ca O	Magnesia Mg O	Soda Na2 O
1	Matteson	S. Fletcher	Artesian	400	3180	3580	1180	Large	Large	Large	None	Large
2	Medina	F. McConoly	Artesian	645	2780	3425	66	Large	Large	Large	None	Large
3	Orr	J. D. Nelson	Well	85	555	640	66					
4	Mandan	Pioneer Pub. Co.	Artesian	140	2163	2303	1056	Large	Trace	Trace	None	Mainly
5	Moorhead	B. Kipples	Artesian	78	582	660	165	Large	Slight	Small	None	Mainly
6	Langdon	N. E. McGrau	Artesian	360	3545	3905	290	Large	None	Trace	None	Mainly
7	Matteson	S. Fletcher	Artesian	445	3155	3600	1140	Large	Mainly	Slight	None	Large
8	Fargo	C. W. Darling	Well	125	565	690	146	Consid.	Large	Large	None	Consid.
9	Michigan	T. J. Moran	....	320	2200	2520	....	Large	Small	Small	Trace	Mainly
10	Sheyenne	F. L. Kermott	....	188	3377	3565	2000	Large	Fair	Small	None	Large
11	Banks	J. G. Walla	Creek	272	1617	1889	38	Large	Small	None	Small	Mainly
12	Banks	J. G. Walla	Spring	150	2182	2332	36	Consid.	Large	None	Slight	Mainly
13	Jamestown	F. J. Latta	Spring	70	540	610	39	Consid.	Consid.	Large	Trace	Consid.
14	Minot	L. S. Foot	Spring	68	237	305	33	Large	Trace	None	None	Mainly
15	Harvey	Harvey Milling Co.	Artesian	388	3327	3715	1617	Large	Consid.	Slight	None	Mainly
16	Park River	C. H. Honey	Artesian	175	4318	4493	2004	Large	Consid.	Trace	None	Mainly
17	Edmore	C. Erickson	....	227	3520	3747	207	Large	Large	Large	Small	Large
18	Rolla	Dr. DePuy	Well	60	605	665	83	Large	Slight	Large	None	Large
19	Mohall	Dr. Fitzmaurace	Well	1690	9634	10324	82	Large	Heavy	Light	Heavy	Large
20	Flaxton	B. W. Goue	Well	128	636	764	33	Some	Consid.	Consid.	None	Consid.
21	Driscoll	H. C. Hallum	....	268	2355	2623	43	Consid.	Large	Large	None	Large
22	Fargo	F. Heath	Well	282	428	710	90	Small	Consid.	Trace		Largely
23	Oakes	W. L. Brown	....	558	1132	1690	511	Consid.	Small	Large	None	Largely
24	Bismarck	I. P. Baker	Well	68	565	633	49	Consid.	Consid.	None	Small	Mainly
25	Richardton	S. D. Pringle	Spring	120	330	450	29	Consid.	Small	Consid.	None	Mainly
26	Erie	S. Mechtel	Artesian	65	3370	3435	1320	Consid.	Large	Small	Trace	Mainly
27	Fargo	F. Heath	Well	300	1190	1490	83	Consid.	Consid.	Small	Small	Mainly
28	Lisbon	R. S. Adams	Artesian	70	2690	2760	660	Consid.	Large	Consid.	Small	Mainly
29	Grandin	J. C. Nelson	Spring	65	720	785	130	Large	Small	Small	Slight	Mainly
30	Minot	L. M. Davis	Well	110	305	415	39	Large	Large	Large	Trace	Consid.
31	Minot	L. M. Davis	Well	105	645	750	39	Large	Large	Large	Trace	Consid.
32	Sharon	A. N. Khostra	Well	315	2100	2415	36	Consid.	Large	Large	Small	Large
33	Enderlin	T. Pierce	Artesian	150	3242	3393	1492	Fair	Mainly	Large	Small	Large
34	Langdon	L. J. Riddington	21 feet	386	1251	1637	198	Consid.	Small	Small	Trace	Large
35	Kenmare	D. Kahelick	Artesian	210	995	1205	174	Large	Small		Trace	Mainly

36	Kenmare	O. L. Wilson		170	340	510	36	Consid.	Consid.	Trace	Trace	Mainly
37	Minot	P. P. Lee		1060	2068	3128	72	Large	Consid.	Large	None	Large
38	Hillsboro	M. F. Lee		340	435	775	52	Consid.	Fair	Small	None	Mainly
39	Dale	J. Clark	16 feet	394	120	514	81	Mainly	Small	Small	Trace	Mainly
40	Lidgerwood	P. H. Mainger		835	2357	3192	178	Large	Consid.	Consid.	Fair	Largely
41	LaMoure	J. Rasmussen	18 feet	1705	9135	10840	620	Large	Consid.	Small	Large	Largely
41	Enderlin	T. Pierce	Artesian	150	2692	2842	825	Consid.	Large	Small	Small	Largely
43	Larimore	T. Radcliff	14 feet	224	336	560	33	Consid.	Trace	Large	Trace	Largely
44	Grandin	J. C. Thorn		208	620	828	40	Consid.	Consid.	Consid.	Fair	Consid.
45	Dale	J. Clark	140 feet	600	1760	2360	33	Consid.	Consid.	Consid.	Consid.	Large
46	Devils Lake	M. F. Whitman		100	3800	3900	1551	Consid.	Consid.	Small	Trace	Large
47	Walhalla	Dr. Graham		490	1370	1860	561	Large	Trace	Large	Slight	Large
48	Lisbon	F. P. Allen		50	2570	2620	726	Consid.	Consid.	Trace	Small	Mainly
49	Lisbon	F. P. Allen		140	2370	2510	1633	Consid.	Consid.	Slight	Small	Mainly
50	New Rockford	O. E. Couch		910	3020	3930	907	Large	Small	Large	Consid.	Large
51	Lisbon	F. P. Allen		680	1385	2065	514	Large	Small	Large	Trace	Large
52	Lisbon	W. G. Crocker	Well	600	1727	2327	557	Consid.	Small	Large	Consid.	Large
53	Forest River	G. B. Sample		896	3284	4180	1269	Large	Large	Small	Large	Large
54	Hope	C. S. Shippy		910	1904	2714	182	Consid.	Consid.	Consid.	Small	Large
55	Hillsboro	L. S. Thorpe	Well	375	417	792	150	Consid.	Small	Large	None	Large
56	Sheyenne	O. E. Nash	Spring	45	185	230	16	Large	Small	Small	Trace	Large
57	Devils Lake	G. W. Moores		320	2658	2978	174	Large	Consid.	Small	Trace	Large
58	Starkweather	Dr. W. C. Fawcett		1140	3265	5405	36	Large	Heavy	Consid.	Small	Large
59	Berthold	F. C. Walters	Well	295	4540	4835	643	Large	Slight	Consid.	Small	Mainly
60	Lisbon	S. C. Patterson	Well	402	886	1288	792	Small	Slight	Small	Trace	Mainly
61	New Rockford	J. F. Goss	Well	305	4715	5020	4538	Slight	Trace	Small	Trace	Large
62	Omemee	A. Milloy	152 feet	985	1290	2275	1200	Small	Small	Slight	None	Large
63	Webster	G. H. Barenalt	22 feet	4144	14092	18236	1237	Medium	Heavy	Light	Trace	Mainly
64	Webster	G. H. Barenalt	Well	258	2716	2974	1960	Large	Slight	Trace	Trace	Heavy
65	Valley City	P. G. Davidson		165	3325	3490	2845	Small	Trace	Small	Trace	Mainly
66	Hankinson	E. Hunger	Well	193	372	565	33	Consid.	Small	Small	Trace	Mainly
67	Fargo	A. Leach	Artesian	365	955	1320	307	Consid.	Large	Large	None	Large
68	Cooperstown	M. Crane	Well	210	1170	1380	165	Large	Consid.	Trace	Fair	Mainly
69	Binford	B. Vogen		145	320	465	25	Large	Trace	Large	None	Large
70	Page	C. W. Dickinson	Well	134	464	598	17	Consid.	Large	Large	None	Large
71	Fargo	C. A. Darling	Spring	66	420	486	9	Large	Slight	Large	Trace	Large
72	Fargo	C. A. Darling	Spring	68	468	536	11	Large	Small	Large	Slight	Largely
73	Litchville	W. A. Wells	1105 feet	1628	3258	4886	2706	Large	None	None	Trace	Mainly
74	Hankinson	E. Hunger		370	1100	1470	90	Consid.	Medium	Medium	Consid.	Large
75	Souris	S. Stone		244	988	1232	57	Large	Large	Consid.	Consid.	Consid.
76	Lisbon	H. S. Oliver	Artesian	120	1253	1373	818	Large	Consid.	Consid.	None	Consid.
77	Buffalo	R. S. Lewis	Artesian	63	3130	3193	1523	Consid.	Fair	Small	Slight	Large
78	Minot	Bottling Works	Artesian	150	545	695	70	Consid.	Small	Trace	None	Mainly
79	Bismarck	W. O. Ward	Well	70	1300	1370	97	Large	Small	Large	Small	Large
80	Petersburg	Wm. Anton	45 feet	40	585	625	20	Consid.	Small	Consid.	None	Mainly
81	Wahpeton	Wm. Huppeler		205	1000	1205	181	Large	Consid.	Consid.	Small	Mainly

82	Minot	L. G. Thume		279	627	906	100	Large	Slight	Consid.	Consid.	Consid.
83	Oriska	J. Mersuer	89 feet	712	1003	1715	101	Large	Consid.	Large	Consid.	Largely
84	Mandan	J. W. Brown	14 feet	161	424	585	17	Consid.	Large	Large	None	Consid.
85	LaMoure	C. W. Davis	950 feet	1359	2439	3798	1728	Consid.	Large	Trace	None	Mainly
86	Fargo	H. Gratius	Well	880	2638	3518	31	Large	Large	Trace	Large	Large
87	Island Lake	G. R. Fox	Well	1644	7440	9084	....	Lerge	Heavy	Consid.	None	Mainly
88	New Rockford	G. E. Fugina	120 feet	325	1005	1330	43	Lerge	Heavy	Large	Trace	Large
89	Hope	B. F. Kraabel	Well	305	1435	1740	363	Large	Large	Large	Consid.	Large
90	Gwinner	N. Peterson	Artesian	60	2550	2610	660	Large	Large	Consid.	Trace	Large
91	Minot	J. H. Lewis		172	773	945	10	Large	Trace	Small	None	Mainly
92	Dwight	C. M. Johnson		307	1750	2057	412	Large	Large	Large	None	Mainly
93	Lidgerwood	Lidgerwood Mill Co	25 feet	175	1200	1375	42	Large	Large	Large	Small	Large
94	Valley City	Cemetery Co.	Well	898	7617	8515	772	Large	Large	Small	None	Mainly
95	Manvel	Creamery Co.	Artesian	1160	5460	6620	3960	Large	Large	Consid.	None	Mainly
96	Turtle Mts.	D. H. McArthur	Spring	230	1256	1486	26	Large	Small	Consid.	Trace	Mainly
97	Milton	H. J. Helgeson	Well	280	5460	5740	4815	Large	Small	Small	Small	Mainly
98	Lisbon	E. Billing	Well	1640	2275	3915	2079	Small	Small	Small	Small	Mainly
99	Fairmount	E. D. Baker	140 feet	212	1033	1245	300					
100	Leeds	Peterson Bros.	Well	1796	5586	7382	148	Large	Large	Consid.	Large	Large
101	Fargo	Rea Bros.	Well	56	590	646	112	Consid.	Consid.	Consid.	None	Consid.
102	Barton	W. Gilman		540	3574	4114	165	Lerge	Heavy	Consid.	Trace	Large
103	Minnewaukan	O. J. Hegge		884	9350	10234	1914	Large	Large	Large	Consid.	Large
104	Lisbon	C. W. Davis	Artesian	154	2676	2830	1683	Large	Small	Trace	Trace	Mainly
105	Hoople	H. N. Hendrickson		1130	3656	4786	115	Large	Consid.	Consid.	Consid.	Large
106	McLean	J. Johnson	Spring	52	494	546	13	Large	Small	Consid.	Trace	Consid.
107	Edgeley	R. R. Davis	Artesian	710	5414	6124	4620	Large	Trace	Small	Trace	Mainly
108	St. Thomas	A. Gaussler	Well	3008	9240	12248	26	Large	Heavy	Trace	Heavy	Large
109	LaMoure	B. N. Stone	Artesian	736	2484	3220	1792	Large	Small	Trace	None	Mainly
110	Maddock	O. A. Stoe		546	2330	2876	1716	Large	Small	Trace	Trace	Mainly
111	Bismarck	P. C. Remington		182	1702	1884	99	Large	Consid.	Small	Trace	Mainly
112	Bottineau	J. N. Greiner	160 feet	86	1204	1290	495	Large	None	None	None	Mainly
113	Cando	H. Lord		124	450	574	33	Large	Small	Consid.	Consid.	Consid.
114	Valley City	P. G. Davidson	79 feet	752	4586	4338	1881	Large	Small	Small	Consid.	Mainly
115	Wilton	E. Syverson	Well	1568	7916	9484	....	Large	Heavy	Consid.	Large	Large
116	Bottineau	D. H. McArthur	160 feet	124	1750	1874	1287	Fair	Trace	Trace	Trace	Large
117	Bismarck	F. Jaszkowick		282	1886	2168	100	Large	Large	Trace	None	Mainly
118	Edmore	O. C. Belseth		506	4046	4552	3013	Large	Consid.	Small	Large	Large
119	Stealing	Wm. Britton	90 feet	132	918	1050	7	Large	Small	Small	Trace	Large
120	Belcourt	J. C. Jensen	30 feet	1422	5222	6644	398	Large	Large	Small	Large	Large
121	Gladstone	M. Rickman		126	540	666	13	Large	Consid.	Small	Consid.	Consid.
122	Pingree	J. Hunt	Well	128	746	874	39	Consid.	Consid.	Consid.	Consid.	Consid.
123	Bismarck	Dr. Quinn	Missouri River	66	252	318	13	Consid.	Consid.	Small	Slight	Consid.
124	Sheldon	G. H. Carr		202	300	502	33	Consid.	Trace	Large	None	Consid.
125	Wahpeton	E. A. Aspinwall	Artesian	158	1113	1271	208					
126	Wahpeton	E. A. Aspinwall	Red River	82	150	232	20					
127	Medina	E. M. Reardon	Well	676	2758	3434	16	Large	Consid.	Large	Large	Consid.

128	Medina	E. M. Reardon ...	Spring	686	2734	3420	30	Large	Large	Trace	Large	Large
129	Park River ..		....	174	626	800	42	Consid.	Small	Small	Consid.	Mainly
130	Barney	H. J. Fitz	Well	1648	11698	12346	30	Large	Heavy	Trace	Heavy	Heavy
131	Zion	F. D. Saylor	253 feet	528	5330	5858	5280	Small	Trace	Small	Large	Mainly
132	Grafton	R. Allen	....	2044	3182	5226	363	Large	Fair	Consid.	Large	Large
133	Barney	H. J. Fitz	38 feet	809	7171	7980	23	Large	Heavy	Large	Heavy	Large
134	Minnewaukan	F. Snore	....	1780	9750	11530	627	Large	Heavy	Heavy	Small	Large
135	Valley City ..	Dr. Platou	Well	304	990	1294	99	Large	Consid.	Small	Heavy	Large
136	Edgeley	C. J. Sturgeon ...	Artesian	290	4676	4956	4550	Small	Slight	Trace	Slight	Mainly
137	Leonard	Wm. Piper	530 feet	308	3786	4174	1320	Large	Consid.	Small	Trace	Large
138	Armstrong ...	D. Campbell	Well	62	346	408	13	Large	Small	Small	Consid.	Largely
139	Langdon	A. Koehmstedt ..	....	500	3824	4324	429	Fair	Heavy	Consid.	Large	Large
140	Mayville	(Ice Water)	Goose River ...	18	24	42	4					
141	Mayville	River Water	Goose River ...	502	1428	1930	269					
142	Fargo	Bottling Works ..	Artesian	172	686	858	244	Large	Consid.	Small	Consid.	Largely
143	Sterling	W. M. Bratton ...	480 feet	580	1420	1900	39	Large	Consid.	Trace	Trace	Mainly
144	Williston	G. F. Rowell	45 feet	154	2190	2244	36	Large	Consid.	Small	Large	Large
145	Langdon	H. D. Alert	Well	1324	3064	6388	600	Large	Heavy	Small	Large	Large
146	Cogswell	E. E. Soule	....	....	.....	1506	760	Large	Trace	Trace	Trace	Mainly
147	Glover	P. Rowan	....	100	404	504	22	Consid.	Small	Large	None	Consid.
148	Dickinson ...	J. W. Currie	....	58	246	304	33	Consid.	Small	Consid.	None	Mainly
149	Monango	W. B. Dille	....	298	1859	2155	1386	Consid.	Consid.	Small	Small	Mainly
150	Willow City .	D. Brigham	60 feet	5386	21474	26860	930	Large	Excessive	Little	Excessive	Large
151	Bye	Peter Benson	....	505	5040	5545	204	Large	Heavy	Large	Trace	Large
152	Hankinson ..	Andrew Bros. ...	Artesian	215	1535	1750	66	Large	Large	Large	None	Large
153	Hankinson ..	Andrew Bros. ...	Artesian	640	3460	4100	171	Large	Consid.	Small	None	Mainly
154	Walhalla	H. C. Mayo	....	515	605	1120	165	Large	Small	Fair	Slight	Mainly
155	Buffalo	S. G. Moore	Well	200	625	825	82	Consid.	Slight	Slight	None	Mainly
156	Orr	J. D. Nelson	Well	223	535	758	89	Large	Slight	Large	Trace	Mainly
157	Orr	H. B. Nelson	Well	210	525	725	82	Mainly	None	None	Slight	Mainly
158	Alice	R. Anderson	....	100	3745	3845	1590	Large	Large	Slight	Slight	Mainly
159	Leeds	W. J. Cassidy ...	....	278	2590	2868	118	Large	Heavy	Fair	Slight	Large
160	Hankinson ...	G. R. Fowler ...	Spring	75	680	755	36	Mainly	Slight	Slight	Slight	Mainly

MINERAL ANALYSIS OF WATERS.

Considerable interest has been manifested regarding the composition of the water in Devils Lake, which body of water is an inland sea without an outlet. It has been claimed that the water is much saltier than in years past. The water has been receeding since the surrounding country has been under cultivation. In the past twenty-five years, at the city of Devils Lake where boats formerly came to the wharf at the edge of the city it is now six miles or more to the present shore line. In October, 1901, a sample of this water was taken by the late Prof. Hall and our examinations showed the following composition:

	Per cent.
Carbon and volatile matter	9.85
Silica, sand, etc.	.15
Magnesium sulfate Mg S 04	25.47
Calcium sulfate C a S 04	1.51
Potassium sulfate K2 S 04	3.29
Iron and alumina	Trace
Sodium Sulphate N a2 S 04	38.28
Phosphates	Trace
Sodium Chloride Na Cl	15.33
Sodium bi-carbonate Na H C 03	5.50
Undetermined	0.62
	100.00

A sample of water from a deep artesian well at Buffalo, N. D., was also examined and found to contain as follows:

	Per cent.
Calcium sulphate Ca S 04	4.11
Sodium chloride Na C l	56.12
Iron and alumina	Trace
Potassium sulfate K2 S 04	2.70
Sodium sulfate Na2 S 04	27.48
Sodium bi-carbonate Na N C 03	7.13
Carbon and undetermined	2.46
	100.00

As showing the composition of the artesian waters, we may give the following as representing about the average for the different wells:

ANALYSIS OF SOLIDS—PER CENT.

	Hunter	Jamestown	Mayville
Organic matter	8.81	2.32	5.75
Sand and silica (SiO_2)...	1.5	.46	1.22
Sulfuric acid (SO_3)......	29.71	40.9	29.86
Lime (CaO)	.70	7.4	7.98
Magnesia (MgO)	Trace	1.19	Trace
Iron (Fe_2O_3)	Trace	Trace	Trace
Alumina (Al_2O_3)	Trace	Trace	Trace
Potassium (K_2O)	1.74	1.5	1.17
Soda (Na_2O)	54.3	40.80	40.62
Phosphates (P_2O_5)	Trace	Trace	Trace
Carbonates and undetermined	12.96	7.15	12.41
	100.00	100.00	100.00

In each of the above waters there are present considerable sodium sulfate (Glauber's salts), and the continuous use of waters charged to such an extent with a salt so largely employed as a purgative for stock cannot be considered as other than harmful.

I cannot do better than to summarize as expressed in bulletin No. 32:

CONCLUSIONS.

I. The water supply for towns should not contain large quantities of solids. According to Dr. Smart, waters are desirable that contain not to exceed three hundred parts, and are to be condemned when they exceed one thousand parts per million. Taking these figures as a basis, it would seem that 500 parts per million would be as high as is permissable for good health, and this would agree closely with Wanklyn's standard. If we take 500 as a standard of purity for solids, then but few, if any, of the waters in the deep artesian wells of the state could be recommended for drinking purposes.

2. If the kidneys must eliminate the excess of soluble mineral salts then the continuous use of these artesian waters might result in kidney trouble if not in gastric disturbance, especially if one was pre-disposed to kidney troubles. Several complaints have been made that such a condition prevailed among the users of these waters.

3. The presence of organic matter in the deep well waters of the state is not to be considered as an indication of sewerage contamination.

4. The chemist can give you but little assistance in interpreting the result of water analysis unless he knows the conditions surrounding the well or water supply, and, therefore, largely influencing the character of the water.

It is not uncommon for parties to send in a few ounces to a pint of water with the request that an examination of the same be made. Those who desire waters examined chemically, should follow strictly the instructions below; if bacteriological examinations are required the matter should be taken up direct with Dr. L. Van Es.

DIRECTIONS FOR TAKING WATER FOR ANALYSIS.

AMOUNT. For analysis of water for sanitary purposes one-half gallon should be sent.

HOW TO SEND WATER. The water should be sent in a new jug, or better in bottles. The jug or bottle should be thoroughly scalded with boiling water and then carefully rinsed with the water from the well. Pump the water directly into the jug or bottle, and do not use any other dish for handling it. Use a new cork for closing the bottle and tie over the top a piece of cotton cloth to keep out the dirt, but use no sealing wax. (Where old corks are used the water will not be analyzed.) Ship prepaid by freight or express to the Agricultural College, Chemical Department, Fargo, N. D.

CHARGES. The Board of Control have fixed a charge of 50 cents for each water analysis for sanitary purposes. Mineral analysis of water from $1.50 upward.

(By answering the following questions you will aid much in interpreting the result of analysis.)

Depth of well ....

When dug ....

Amount of water furnished per day ....

Distance of well from nearest barnyard.... .. ..

Distance from nearest privy ....

Distance from place where slops from house are thrown.....

Kind and distance of building nearest to well..............

Does the ground slope towards the well from house, barn or privy ....

Has there been any apparent recent change in condition of water ....

What reason, if any, have you for suspecting the water to be bad ....

Are any persons using the water in poor health ....

REMARKS.

....

....

....

....

Name .... Address ....

NORTH DAKOTA AGRICULTURAL COLLEGE

Government Agricultural

Experiment Station

OF

NORTH DAKOTA.

Bulletin No. 67.

PAINTS AND PAINT PRODUCTS.

By E. F. LADD AND C. D. HOLLEY.

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

FARGO, NORTH DAKOTA, U. S. A.,
December 1905.

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PAINTS AND PAINT PRODUCTS.

By E. F. Ladd and C. D. Holley.

INTRODUCTION.

The legislative assembly of North Dakota, at its ninth session, enacted into a law a bill, introduced by Senator McArthur, of Bottineau, for the purpose of preventing adulteration and deception in the sale of paints. This law goes into force January first, 1906.

It is made the duty of the director of the experiment station, together with his assistants, to see that this law is enforced. Unfortunately no appropriation was made for carrying out this work and whatever is accomplished must be done as a personal matter by those who are interested in seeing that the law is properly enforced and by the experiment station whose officers are charged with the investigation of paints. This law has been severely criticised by some paint manufacturers and by others it has been looked upon as a step in the right direction.

Since this is the first comprehensive law of the kind passed by any state legislature it is not unlikely that the measure may be imperfect and that experience will show the necessity for changes at the coming session of the legislature. It is not unlikely that it will be found wise to specify, as is done in fertilizer laws, the manner in which the analyses shall be expressed on the label. Certain manufacturers have maintained that this law is unconstitutional. This is a matter for the courts to decide and at the present time, it is announced that proceedings will be started early in January by certain paint manufacturers to prevent the enforcement of this law. Therefore, it seems well to place before the public such information as we have regarding paints and paint products and to discuss in some detail the character of the various products entering into the preparation of the paints.

That there are some paints upon the market which are not desirable products cannot be denied and the people have as much right to know which paints are what they are represented to be as they have to know that commercial fertilizers are what their manufacturers claim for them. It should be borne in mind, however, that if certain well-known paints are not in accord with generally accepted views as to what constitutes a perfect paint, we should not at once conclude that the products are entirely worthless. We may as well be justified in concluding that some of these combinations are superior for the purposes intended. The paint that stands the test of twenty or twenty-five years and gives general satisfaction is not to be turned aside simply because it is shown that the paint is not in chemical composition what we had assumed to be the recognized standard.

On the other hand, those paints which contain constituents which are recognized as lowering its value, or injuring its quality and which the unscrupulous manufacturer tries to hide from the public, by carefully worded advertisements and guarantees, should be made known to the consumer in order that he may make an intelligent selection of the paint he will employ. Thus far we have not found a single statement from a reliable source showing that the presence of either water or alkaline soap solutions add anything to the value of paint.

With regard to inert minerals entering into the pigment, there is much more to be said. Some of these may have value when properly mixed in combination with the true basic constituents of paint pigments. On the other hand, when these constituents constitute the bulk of the paint, and the public are lead to assume that the product is made up of white lead or white lead and zinc, then a fraud is being practiced which is no more honorable on the part of the manufacturer of paints than it is on the part of the manufacturer of commercial fertilizers.

In the present bulletin we shall deal only with white paints, intended for inside and outside use, leaving all other shades to be discussed in future bulletins when the work is more fully completed. The subject of oils, oil substitutes and dryers will also be fully discussed by Mr. Holley in our forthcoming annual report and therefore will not be considered at this time. In the analyses as given in these pages we have used the term "vegetable oil" rather than linseed oil, assuming, of course, that the product is pure linseed oil.

In some cases, however, further work is necessary in order to determine the true character of some of these oils. It is possible that in some instances, the seed from which the oil has been extracted contained no inconsiderable amount of foreign weed seed, rape seed, etc. It is possible, too, that there are substitutes which to some extent, have found their way into some of these oils but this will be discussed more fully at an appropriate time.

The term "volatile oil" should mean turpentine as given in these analyses. In some instances it is known that other than turpentine is included under this head. A further separation and study of these products will be made and the data presented in a future report.

As showing what others interested in paint work, have found in their experience I quote from Sabin: *

"No turpentine or benzine should ever be allowed about the premises while this work is going on. Most of the failures of lead and zinc paints is due to the use of these volatile thinners, ———."

Jennings, in Paint and Color Mixing says, "There is not much doubt that the best pigments may be replaced with others somewhat inferior without so much detriment to the quality of the paint as if linseed oil is replaced by some other oil. It is quite necessary that pure linseed oil be used in the manufacture of all paints, and although there are one or two substitutes on the market which may be employed in very cheap work, no attempt should be made to execute a really good job unless pure linseed oil is used."

He further says, "It is very important that the turpentine used in the paint be pure. American turpentine is mostly used. Owing to its high price it is sometimes adulterated with disastrous effects upon the paint."

If the paint authorities consider it so important that only pure linseed oil and pure turpentine should be used in order to secure the best results and if paint manufacturers insist that only the purest and highest grade of linseed oil and turpentine shall be employed in thinning paints in so far as may be found necessary when they are ready for use, then why should these manufacturers be permitted to use substitutes for oils which are of questionable value without informing the public of their presence. The very fact that some manufacturers are opposing the law, so strenuously at the present time and are proposing to fight it through the courts, hoping to defeat the purpose intended by the legislature, indicates that there is some reason for keeping away from the public the desired information.

There are certain paint manufacturers whose goods do not, under the present law, require any labelling and other manufacturers have indicated their intention to so modify their formulas

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*Industrial and Artistic Technology of Paint and Varnishes, page 312.

as to make it unnecessary to label their goods for North Dakota trade. Certainly, opposition to the present paint law will not result in benefit to manufacturers who will later need to explain their attitude before the public, but the law must react to the benefit of those who are willing to comply with its requirements.

I believe our readers will be interested in, and benefited by, reading quotations taken direct from the paint literature sent out by the paint manufacturers themselves. With regard to the character and value of certain constituents in the pigments and liquid portions of paints as now found upon the markets we quote the following:

In Paint in Architecture, Stanton Dudley says, "The universal approved menstrum for protective paints is pure linseed oil. There is no known substitute for it though the market is full of adulterated oil and paint containing it————."

"The usual adulterants are petroleum oil, cotton seed oil, rosin oil, and fish oil. In prepared paints the commonest adulterants are alkaline, emulsifying agents which permit of the introduction of cheap petroleum products and water."

"If all ready-mixed paints were made containing a pigment of pure linseed oil, turpentine and Japan dryer they would probably long since have displaced all other forms of paint. Unfortunately, however, the desire for cheapness has led to the discovery that by the addition of alkalies, oil can be made to mix with water and benzine has been found to be a possible substitute for turpentine."

"Adverse experience with such compounds is the secret of the commonest protest against ready-mixed paints."

Heath & Milligan Manufacturing Company say, "Linseed oil is conceded to be the life of the paint." They further say, "It is linseed oil which gives the life, elasticity and durability to the combination, holding the pigment together and to the surface, while the pigment is that which hides, covers, protects and prolongs the life of the linseed oil. They further say, "Not a drop of anything but pure linseed oil and turpentine should be added to the best prepared paint and they should only be added as noted in the directions."

They further say, "The market is so flooded with substitute linseed oil and bogus paint oils of various kinds, that great care should be taken to get pure linseed oil of some reputable make. If any oil other than pure linseed oil is used in the reduction of this paint, we will not be responsible for results and will not guarantee satisfaction from its use."

In Paint Queries, Patton has the following:

What hurts the quality of paint most?

Answer: Adulteration in the liquids.

What are the most common adulterants in the liquids?

Answer: Water and benzine.

How can one easily learn if these adulterants are used?

Answer: You can at once detect the presence of benzine by the smell.

If water is in the paint, a piece of gelatine will get soft if left in the paint over night.

Will gelatine get soft in pure linseed oil paint?

Answer: No.

Why is water put in paint?

Answer: To cheapen it.

Is that the only reason?

Answer: No.

What else does water do in paint?

Answer: It makes paint look thicker.

What is the object of that?

Answer: To cause the people to believe they are getting more for their money.

In what way?

Answer: They are told that pure oil costs less per gallon than paint, so they can add the oil and make that saving.

What is the truth about this?

Answer: Paint makers furnish the water which costs nothing and you furnish the oil. You are the "cat's paw."

Hammar Brothers White Lead Company say, "We knew that every new, improved patent process lacks some one possible necessity that has made and kept Old Dutch Process the standard of quality for 400 years or more. It costs less money to put up a factory to make quick process lead but it does not make as good lead."

In Facts and Figures, Patterson, Sargent Company say, "No one can deceive us with a "quick process" or adulterated white lead, or a "new process" linseed oil, cotton seed, corn oil, or petroleum mixtures; and we do not overstate the case when we say that fully one-half of the so-called linseed oil on the market today is adulterated."

They further say, "Do not thin with or add anything but pure raw linseed oil, except in the following cases."

They further say, "Don't paint during wet or frosty weather."

In paints, why, how and when we find the following:

"The ready-mixed paints have always contained zinc white and many of the cheaper kinds also contained water and alkali (potash or soda) and so little linseed oil that they gave very poor service; and ready-mixed paints of all kinds fell into bad repute because of the faults of the worst kind."

Further it says, "But in every case those who know most about paint insist that it shall contain no water and no oils beside pure linseed oil."

The National Lead Company say, "Linseed oil is the only oil that has the important quality of drying paint." "Other oils will not dry but leave the paint soft so that it may be easily rubbed or scraped off."

They further say, "A great many packages are labelled "Pure White Lead," which are not pure white lead at all and sometimes do not contain a trace of white lead."

Patton, in Color Schemes for House Painting says, "Many paints contain water. Water, we need hardly state, has absolutely no paint value. It is used as an adulterant, to displace oil; and, more serious, its presence indicates that an alkali has been used. Oil and water will not mix without the addition of an alkali. The water, the oil, and the alkali make a thick, "livered" mixture, and those who do not know the "trick of the trade" think they are getting more for their money. Furthermore, the alkali injures the oil, shortens its life. If a paint contains water it is not a good paint."

Carter White Lead Company says, "There is no bleacher, no zinc white, no barytes, no water, no mineral oil—ingredients that have no place in a pure product."

Sears, Roebuck & Company, in How to Paint say, "Be sure that the oil you are using is absolutely pure as there is nothing on the market just as good."

In a little pamphlet being distributed by paint men we have the following, "Paint will blister, peel, etc., if inferior oil, etc., are used as thinners. Thin with nothing but pure raw linseed oil, except where it is necessary to use turpentine. Paint most certainly will not adhere to a damp surface."

We have quoted from paint men themselves in order to show that those who have spoken upon the subject condemn the use of substitutes for linseed oil. These paint men themselves say they will not be responsible for the results if anything but pure linseed oil is used in reducing paints. If this is true, then why should the paint men "dope" their paint with water, alkali, etc. In other words, if it is not good enough for the consumer to use why do the paint men put these constituents in? If water and alkali constitute a fraud, why should not the public know it and have an opportunity to judge of the character of the paint which they desire to use upon their buildings?

The further discussion of this subject we leave for some future occasion. For the present, the public may well draw their conclusions from the statements quoted from the paint manufacturers themselves as given above, and from the result of analyses as given in the following pages:

THE WHITE PIGMENTS.

Paint has been used for decorative purposes from prehistoric times. Its principles of manufacture and essential components are very generally known. It is composed of the PIGMENT which gives the paint its color and the oil or other liquid which forms the fluid part of the paint, technically called the VEHICLE.

The pigment should be permanent under the action of light and air. It should have good spreading or covering qualities and above all the power to hide or obscure thoroughly the surface over which it is spread.

The vehicle should be capable of drying or hardening in a suitable length of time, firmly cementing the particles of pigment to each other and to the surface to which the paint is applied and should remain unaltered by light, air and ordinary conditions of moisture for several years. A paint properly made and applied with reasonable care and under suitable conditions should not crack or chalk readily.

BASIC CARBONATE OF LEAD—Trade Names—White Lead, Corroded Lead.

White lead is the most important of all our pigemnts and is among the oldest, the native carbonate, cerussite having been in common use among the Romans. These deposits being limited in extent and distribution gave increased incentive for the manufacture of an artificial white lead reference to which is made as far back as 1622 and with few modifications is in extended use yet and yields a product which is preferred by many painters to the lead manufactured by most of the newer processes.

White lead is a basic lead carbonate the better forms of which correspond to the formula $2PbC03, Pb\ (0H)2$ in which there are two molecules of lead carbonate to one of lead hydroxide. As it appears on the market, white lead is either dry or mixed with about nine per cent of raw oil. However, there are some white leads on the market, termed pulp white leads which contain considerable amount of water along with the oil, it being claimed that these leads work easier under the brush.

Prepared according to the Dutch Process or its modifications, white lead is a very heavy white powder, having a specific gravity of about 6.47, a cubic foot of the dry powder weighin gabout 185 pounds. According to Hurst, "white lead possesses all the good qualities desired by a painter—viz., good color, body, covering power and permanency. It is distinguished from all other pigments by the ease with which it mixes with oil and by forming a paint which readily flows from the brush, whereas most pigments, as for instance, barytes, tend to work what the painter calls slimy or livery, and streaky; white lead does not exhibit this property, but flows freely and evenly fromy the brush."

Paste white lead, usually sold in kegs, is very frequently adulterated, the pigment most used for this purpose being barytes, which very nearly approaches white lead in specific gravity and on that account is not so readily detected and its coat is only a very small fraction of that of white lead.

Sublimed White Lead—This product is so named because it is prepared by a sublimation process. The product is obtained directly as a very fine, impalpable, white powder, without grinding. Chemically it is very different from ordinary white lead, being apparently a basic sulphateof lead and as prepared by the Picher Lead Company of Joplin, Mo., has approximately the following constitution:

Lead sulphate	75 per cent
Lead oxide	20 per cent
Zinc oxide	5 per cent

The lead oxide is present not as the yellow litharge but apparently as a white oxy-sulphate. Its presence has been found to greatly increase the body of the paint, making it entirely different physically from ordinary lead sulphate. The zinc oxide is incidental to the manufacture.

The specific gravity of sublimed white lead is 6.2 approximately that of ordinary white lead. It exceeds in the fineness of the particles the ordinary grades of white lead and is, at least, equal to them in whiteness, body, covering power and wearing qualities. It differs from the ordinary white leads in being nonpoisonous and resists the blackening action ofthe sulphur compounds of sewer gas and of fuel gases to a much greater degree.

Zinc Oxide—Trade Names, Zinc White, Chinese White.

Zinc white is used very extensively at the present day as a pigment and constitutes nearly 50 per cent of the total pigment in the majority of mixed paints. Being an artificial product, its composition varies widely and its price governed accordingly. Some of the cheaper oxides contain sulphate of zinc which is considered harmful as it is soluble in water and is liable to cause the paint to streak.

The following analyses given by G. H. Ellis in his treatise on White Paints fairly represents the composition of the commercial zinc oxides:

	Zinc White.	Zinc White.	Zinc White.	Zinc White.
Zinc oxide	82.84	96.00	93.23	93.23
Lead sulphate	15.57	3.57	4.81	4.81
Zinc sulphate	1.60	.....	.....	.....
Lead oxide	.....	.....	.....	.....
	100.01	99.57	98.04	100.00

Zinc oxide is a rather bulky, fine white powder, having a specific gravity of about 5.6. It generally has a slightly bluish tinge. It is unchanged by exposure to air and light, sulphur gases having no visible action asthe sulphide formed is white. Hence as a pigment it is very permanent. For preparing a still paste in which form it is often sold, it requires about 22 per cent linseed oil, a much larger proportion than is required by any other pigment. The chief fault with zinc white is its want of body, i. e, hiding the surface over which it is spread, which is not equal to that of white lead, though its covering power is considerably better.

Zinc Lead White—This pigment which has made its appearance within the last few years and which is practically unknown to the general public is prepared from low grade zinc-lead ores which also usually carry small quantities of copper, silver and gold, the latter metals being exhausted after the removal of the zinc and lead. As prepared, it is apparently a molecular combination of zinc oxide, lead sulphate and small proportions of lead carbonate and oxide. The combination, if it may be so termed, being affected at a high temperature while the metals are in the form of vapor, the union is far more intimate than could be obtained by grinding together the separate component pigments.

In physical appearance the zinc lead whites closely resemble a good grade of zinc oxide, but their specific gravity is higher and their density greater. This difference becomes more noticeable on grinding with oil, the proportion of oil taken up being much nearer to the figure for Dutch process white lead than to that for zinc oxide. The density for Dutch process white lead than to that for zinc oxide. The density or obscuring power of the resultant paint places it in the lead rather than in the zinc class. The chief objections made to it are that it is not always uniform in composition or in color. An average of a large number of analyses gives it the following average composition:

Lead sulphate	48.10
Lead carbonate	0.50
Lead oxide	0.60
Zinc oxide	50.50
Zinc sulphate	0.30

G. H. Ellis, however, reports some analyses of zinc lead whites carrying from 1,16 to 5.12 per cent sulphate and considers this constituent in appreciable quantities as decidedly harmful.

BARIUM SULPHATE—Trade Names—Barytes, Blanc Fixe.

Barytes is one of the most important white pigments at the disposal of the paint manufacturer and ranks next to white lead and zinc white as to the extent of its use although its qualities as a pigment are much inferior. It occurs native in large quantities forming the minerals, heavy spar and barytes.

Barytes, is a fine heavy, white powder, insoluble in acids and alkalies, specific gravity about 4.6. It has more or less of a crystaline structure and in body is much inferior to white lead or china clay.

Blanc Fixe or Artificial Barytes is obtained as a fine precipitate when sulphuric acid or a sulphate is added to a solution of a barium salt and is thus obtained as a by-product in some of the chemical industries. Chemically, it is barium sulphate the same as barytes. It has greater coloring power, and body and is more amorphous than the natural barytes. It is also more expensive.

Thorp sums up the properties of barium sulphate as a paint pigment as follows:

"Barytes is very heavy, is not effected by uslphur nor other chemicals and may be mixed with all pigments. It has little body and does not work well in oil, having a streaky appearance when applied, and drying very slowly. Owing to its weight, one of its chief uses is to adulterate white lead."

SULPHIDE OF ZINC WHITES—Trade Names—Charlton White, Lithophone, Ponolith, etc.

During the past twenty-five years considerable attention has been given to the manufacturer of zinc sulphide whites and at the present time they are being manufactured on a large scale and are found on the market under a variety of names as indicated above.

Zinc sulphide possesses what to the painters is of great importance, "body," i. e., opacity or the ability to hide or obscure the surface over which the paint is spread. It, however, possesses the defect that its color is apt not to be good but by introducing other bodies and preparing the sulphides in a special manner, a pigment having good color and good "body" may be obtained. The exact composition of the pigment will depend upon several factors, the proportion between the barium and zinc salts used may be varied, while duration of the calcination to which the pigment is subjected will influence the result by increasing the proportion of oxide in the pigment.

As made by this process, Orr's white has the composition—

Barium sulphate, BaSO4	69.915	per cent
Zinc sulphide, ZnS	14.698	per cent
Zinc oxide, ZnO	13.337	per cent
Water	2.050	per cent
	100.000	

A sample of lithophone, another of the zinc sulphide whites examined by Hurst had the following composition—

Barium sulphate, BaSO4	67.96	per cent
Zinc oxide, ZnO	7.32	per cent
Zinc sulphide, ZnS	24.85	per cent

The zinc sulphide whites have a body usually equal to that of white lead and often superior to it and also possesses the advantagesof not being discolored by hydrogen sulphide and of being non-poisonous. They mix well with all pigments except those having lead or copper as their base. In which case, they are apt to cause a black discoloration due to the sulphur they contain. They are used chiefly for inside white house paints, for which purpose they find a very wide use in Europe and their use is extending rapidly in this country.

CALCIUM CARBONATE—Trade Names—Paris White, Spanish White, English White or English Cliffstone, Whiting, Marble Dust.

Calcium carbonate is sold under all of these names and each corresponds to the formula $CaCO_3$, but there may be considerable difference in their physical properties which will be noticed later. Calcium carbonate occurs native in large masses, widely distributed. The variety used as a paint pigment is chalk. Some of the highest grades of which are found in France and England.

For use as a pigment the crude chalk is ground to a fine powder, settled in water to free it from coarse particles and finally dried very carefully avoiding an excess of heat which convets the calcium carbonate into calcium oxide which has powerful alkaline properties acting vigorously on the oil with which it may be mixed. As prepared in this way it is usually sold under the name of whiting. Paris white is a finer quality of whiting due to more careful grinding. Spanish white is an old name given to Paris white which has been dried in the open air. Marble dust is a very cheap form of calcium carbonate obtained from marble.

Whiting is a dull white powder of an amorphous character, moderately heavy, having a specific gravity of about 2.6. It is insoluble in pure water, but in water containing carbonic acid gas it is soluble to quite an extent. It is subject to the defect that when mixed with oil it loses its white color and turns a dirty grey. Mixed with about 18 per cent linseed oil it forms our commercial putty. Hurst states that it is juite permanent as a pigment. Its capacity for oil is high, requiring nearly three times as much oil to grind into a stiff paste as white lead.

Calcium Sulphate—Trade Names—Gypsum, Terra Alba, Mineral White.

Gypsum is a mineral found in many parts of the world, chemically it is calcium sulphate having two molecules of water of crystallization. For use as a paint pigment the native mineral is ground and treated in exactly the same way as barytes. When heated to 300° F. it loses its water of crystallization and becomes he commercial plaster of Paris, which has the well known property of combining with water, forming a hard rock-like mass, serving many ornamental and useful purposes.

Calcium sulphate is also prepared commercially, being a by-product in several chemical industries.

Gypsum as it appears on the market is a fine bluish-white powder, much lighter in weight than white lead or barytes but is rather heavier than china clay or zinc white. Hurst states that its body is not as good as that of white lead and is rather transparent when mixed with oil but mixes well with water, being slightly soluble in the latter liquid about one part in 500.

China Clay—This pigment like the preceding one is widely distributed in nature and only requires levigating and drying to prepare it for use as a pigment. China clay is essentially a hydrate silicate of alumina, the average composition being—

Silica, SiO_2	47 per cent
Alumina, Al_2O_3	40 per cent
Water, H_2O	13 per cent

which corresponds to the formula—

$2SiO_2. Al_2O_3. 2H_2O.$

But as a rule the composition varies somewhat according to the locality in which it is found.

As it appears upon the market it is a fine white amorphous powder, having slight adhesive properties. It has a specific gravity of 2.2 being the lightest of a ll white pigments. It is insoluble in water and as a pigment it is quite permanent, but when mixed in oil it loses its body and becomes more or less transparent.

SILICA—Trade Names—Silex, Silver White.

This pigment is usually prepared by grinding quartz to a very fine powder which after careful screening or levigating to free from the coarser particles is ready for the market. In oil it possesses very little body or obscuring power but when in a sufficiently fine state of division possesses considerable covering power. It is at the present time finding considerable use in mixed paints.

OTHER WHITE PIGMENTS—Practically, the only white pigment in use in this country outside of some of the other very slightly used lead whites, are magnesium silicate, sold under the trade names of talc or ground soapstone, and barium carbonate. But the occurrence of these two pigments in paints is so rare that they will not be considered in detail.

COMPARISON OF THE PROPERTIES OF SOME OF THE WHITE PIGMENTS—Pigments possess three essential properties available for paint making, viz., color, body and covering power. A series of experiments was carried out by George H. Hurst to ascertain the coloring power of various white pigments. Ten grams of each white was taken and mixed with a quantit y of black to produce a uniform grey tine.

	Grams of black used.	Coloring power.
White lead	1¼	125
Zinc white	2	200
Barytes	1	100
Whiting	2	200
China clay	2	200
Gypsum	1½	150

By *covering power* is really meant the spreading color of a pigment, that is, when mixed with oil, etc., into a paint of suitable consistency, this paint can be spread over a certain extent of surface.

Hurst reports the following series of experiments on the covering power of several of the white pigments. Two grams of each were weighed out and mixed witrh sufficient raw linseed oil as would enable them to be rubbed over the surface of glass plates and the extent of surface covered by each was observed.

White lead (Dutch process)	760
Zinc white	1152
Barytes	1144
Gypsum	1440
Orr's White (Charlton White)	1500

"The quality of a pigment must not be judged solely from the point of view of its covering or spreading power,as gypsum would be considered one of the best pigments for oil while, as a matter of fact, it is one of the worst." The question of pigments retaining their whiteness on being mixed with oil is also very important. Barytes and gupsum are rather deficient in this respect while whiting is notably so as shown in putty.

"By body is meant the power of hiding the surface over which the pigment or paint is spread. Thus while the covering power of zinc white is better than that of white lead its body is far inferior." Body is one of the most important, if not the most important, property of a pigment. Hurst places the following pigments in the following order as regards body, "white lead, zinc white, barytes, gypsum, the latter being very transparent." China clay is also more or less transparent. Whiting or calcium carbonate in its various forms would probably be placed along with barytes, according to its quality.

The quality of linseed oil required to grinw some of the white pigments into a stiff paste is given by Hurst as follows:

White lead	7½ per cent of oil
Zinc white	22 per cent of oil
Barytes	7 per cent of oil
Calcium carbonate	18 per cent of oil

The cost of the various pigments is of prime importance to the paint manufacturer and the following table of quotations from the November number, 1905, of "Drugs, Oils and Paints," Philadelphia, under the heading of "Current Wholesale Prices" will be of interest.

Nameof Pigment	Cents per pound.
American white lead, dry, in bbls	6 1-2 to 7
Sublimed white lead, carload lots	5
Standard zinc lead white, car lots	3 3-4
American zinc lead white, dry..	4 1-2 to 5
Barytes, per ton, $13.00 to $25.00	65-100 to 1
China clay, per ton, $14.00 to $20.00	7-10 to 1
Whiting, Commercial by the 100 lbs. $55-$65	55-100 to 65-100
Paris white, English Cliffstone	1
Terra Alba, per ton, $9.50 to $15.00	48-100 to 3-4

Silex or lithophone is not given but a recent number of the Oil, Paint and Drug Reporter gives the following quotations:

Lithophone	3 3-4 to 7
Silex, per ton, $12.00 to $40.00	6-10 to 2

Regarding the use of pigments other than white lead and zinc white Sabin* states the following:

"The vast majority of houses inthis country are painted with white-lead paint, either pure or (more commonly) adulterated with barytes (barium sulphate), terra alba (sulphate of lime), whiting (carbonate of lime), or other less important sophistications. Carbonate of barium is sometimes used instead of the sulphate. These barium compounds are the least objectionable, being in fact substances chemically inert and of stable composition; but they are practically without coloring power being nearly transparent in oil, and while they probably help to protect the wood they are really used only to cheapen the paint, and commonly to increase the profit to the maker or dealer; not at all for a benefit to the consumer."

In discussing zinc white he says, "White zinc is also an important and valuable white paint; zinc paint is harder than lead paint, and a mixture of zinc is therefore regarded by many as better than pure lead, especially for finishing coats. It is commonly thought to be of a purer white than white lead, and is largely used on interior work especially; when added to white lead it is usually in the proportion of one-third to two-thirds lead."

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*Technology of Paint and Varnish, page 311.

ANAYSIS OF WHITE LEADS.

Station No.	Net Weight	White Lead	Zinc Oxide	Barium Sulphate	Calcium Carbonate	Silica	Clay	Undetermined
10 Globe White Lead ..	13.5 oz.	9.98	12.00	76.28		1.10		0.64
11 Gold Seal White Lead .... Minnesota Linseed Oil & Paint Co., Minneapolis, Minn.	15.4 oz.	64.73	3.60	30.43		0.76		0.48
12 Park White Lead, Park Lead Works	14.8 oz.	4.69	12.50	75.72	5.89	0.67		0.53
24 American White Lead Premium Brand	15. oz.	3.34	8.96	72.35	4.52		10.83*	
37 Cartel White Lead, Carter Lead, Chicago, Ill	31.5 oz.	99.28						0.72
52 White Lead .... Sample sent for analysis		54.69	17.38	27.57				0.36

* Silica and alumina calculated as clay.

No. 7. Gray Mixed Paints.

Minnesota Linseed Oil & Paint Co., Minneapolis, Minn.
Net weight—3 lbs., 8 oz.
Fluid portion contained approximately 10 per cent naphtha.

Pigment	Per cent.
Lead calculated as white lead	57.72
Zinc oxide	28.32
Calcium carbonate	7.77
Color and undetermined	6.19
	100.00

No. 8. Ready Mixed Blue Paint.

Armstrong Paint Co., Chicago, Ill.

Net weight .... 2 lbs., 14 oz.

Pigment	Per cent.
Lead calculated as white lead	13.68
Zinc oxide	25.08
Calcium carbonate	34.93
Barium sulphate and color	26.31
	100.00

No. 9. Peoples' Prepared Paint.

Outside white, ready mixed for use. Manufacturer not given.

Net weight	13.5 oz.
Capacity of can	0.30 quart
Contents	0.23 quart

Fluid portion not pure linseed oil.

Pigment	Per cent.
Lead calculated as white lead	2.27
Zinc oxide	44.44
Calcium carbonate	11.54
Gypsum	40.62
Silica, etc	1.13
	100.00

No. 36. Prepared Gloss White for Outside Use.

The Sherwin Williams Co.

GUARANTEE—"We guarantee that this paint when properly used, will not crack, flake or chalk off, and will cover more surface, work better, wear longer and permanently look better than other paints, including pure white lead and oil.

We hereby agree to forfeit the value of the paint and the cost of applying it, if in any instance it is not found as above represented."

Net weight	4 lbs., 2 oz.
Capacity of can	1.03 quart
Contents	0.98 quart
Pigment per cent by weight	63.8
Fliud portion	36.2
	100.0

Fluid portion	Per cent.
Vegetable oil	93.5
Volatile oil	2.1
Water	4.4
	100.00

Pigment	Per cent.
Lead calculated as white lead	44.52
Zinc oxide	47.91
Calcium carbonate	4.64
Silica	1.24
Alumina	0.78
Undetermined	0.91
	100.00

No. 38. Monarch Mixed Paint—Inside White.
Senour Manufacturnig Co., Chicago, Ill.

Guarantee—The contents of this package is composed of linseed oil, turpentine, lead and zinc, and we guarantee it to be an absolutely pure paint, free from benzine, water or alkalies of any kind and to give satisfaction in every instance where directions are followed.

Notice—This is not a chemical or patent paint. It is made of white lead, zinc and pure linseed oil and is therefore a body paint and requires to be rubbed out like lead and oil. One brushful will go as far or farther than two of other brands of mixed paints.

Net weight	14.2 oz.
Capacity of can	0.30 quart
Contents	0.24 quart
Pigments per cent by weight	62.8
Fluid portion per cent by weight	37.2
	100.0

Fluid Portion	Per cent.
Vegetable oil	77.9
Volatile oil	22.1
Water	0.0
	100.00

Pigment	Per cent.
Lead calculated as white lead	18.84
Zinc white	80.45
Undetermined	0.71
	100.00

No. 39. Patton's Sun-Proof Liquid Paint, Outside White.
Patton Paint Co., Milwaukee, Wis.
No guarantee given on label of can.

Net weight	3 lbs., 2 oz.
Capacity of can	1.02 quart
Contents	0.91 quart
Pigments per cent by weight	62.2
Fluid portion per cent by weight	37.8
	100.0

Fluid Portion	Per cent.
Vegetable oil	92.7
Volatile oil	7.0
Water	0.3
	100.00

Pigment	Per cent.
Lead calculated as white lead	26.14
Zinc oxide	56.64
Calcium carbonate	3.19
Silica	13.10
Alumina	0.26
Undetermined	0.67
	100.00

No. 40. Gilt Edge House Paint, Inside White.
Farwell, Ozmun, Kirk & Co., St. Paul, Minn.
"Strictly Pure."

"Gilt Edge House Paints are composed of pure carbonate of lead, oxide of zinc, pure linseed oil and enough turpentine and Japan to insure correct drying and working qualities. Our outside white contains only lead and zinc for pigment, and is strictly pure. The light tints and other shades contain as coloring matter, the best oxides, ochres and chemically prepared colors to be obtained."

The inside white bears a special label, "Don't use for outside work."

Net weight	3 lbs.
Capacity of can	1.04 quart
Contents	.99 quart

Pigments per cent by weight	62.9
Fluid portion	37.1
	100.0

Fluid Portion		Per cent.
Vegetable oil (contains large amount of resin)		60.1
Volatile oil		39.9
Water		0.0
		100.00

Pigment		Per cent.
White lead		0.00
Lead sulphate		2.57
Zinc oxide		65.81
Lithopone		30.79
Barium sulphate	20.20	
Zinc oxide	4.46	
Zinc sulphide	6.13	
Silica		0.28
Undetermined		0.55
		100.00

No. 41. "N. W." Mixed Paint—Outside White.

T. L. Blood & Co., St. Paul, Minn.

"Unexcelled for durability, fine finish and covering capacity."

"The pigment of the 'N. W.' paint is composed of carbonate of lead, oxide of zinc and colors, thinned with pure linseed oil and sufficient turpentine, Japan and spirits of turpentine to insure general working qualities. No other materials enter into its composition."

"When properly applied, we guarantee our 'N. W.' paint to give entire satisfaction as to durability, covering capacity and fine finish."

Net weight	3 lbs., 5 oz.
Capacity of can	1.03 quart
Contents	.89 quart
Pigment per cent by weight	62.1
Fluid portion per cent by weight	37.9
	100.0

Fluid Portion	Per cent.
Vegetable oil	86.7
Volatile oil	10.5
Water	2.8
	100.00

Pigment	Per cent.
Lead calculated as white lead	31.32
Zinc oxide	68.14
Undetermined	0.54
	100.00

No. 42. Cottage Colors—Outside White.
Bradley & Vrooman Co., Chicago, Ill.
"Unequalled for fineness and durability."

GUARANTEE—We guarantee that when properly applied on a surface in the proper condition, Crown Cottage Colors, will give better satisfaction than any other paint (including white lead) and in all cases where it does not and it is the fault of the material used we will do the work over again at our expense.

Net weight	3 lbs., 3 oz.
Capacity can	1.05 quart
Contents	0.99 quart
Pigment per cent by weight	63.0
Fluid porton per cent by weight	37.0
	100.0

Fluid Portion	Per cent.
Vegetable oil	92.8
Volatile oil	6.8
Water	0.4
	100.00

Pigment	Per cent.
Lead calculated as white lead	25.66
Zinc oxide	54.25
Calcium carbonate	19.42
Undetermined	0.67
	100.00

No. 43. Best prepared Paint—Outside White.
Heath & Milligan Manufacturing Co., Chicago, Ill.
No guarantee given on label.

Net weight	4 lbs., 2 oz.
Capacity of can	1.06 quart
Contents	1.01 quart
Pigment per cent by weight	63.57
Fluid per cent by weight	36.43
	100.0

Fluid Portion	Per cent.
Vegetable oil	89.55
Volatile oil (apparently not pure turpentine	9.70
Water	0.75
	100.00

Pigment	Per cent.
Lead calculated as white lead	43.45
Zinc oxide	45.75
Calcium carbonate	10.39
Undetermined	0.41
	100.00

No. 48. Seroco Ready-Mixed Paint—Outside White.
Seroco Paint Mfg. Co., Chicago, Ill.
Obtained from Sears, Roebuck & Co., Chicago.

"We guarantee our paint to wear for five years if these directions (given on label) are carefully followed."

Net weight	3 lbs., 2 oz.
Capacity of can	1.01 quart
Contents	.96 quart
Pigments per cent by weight	63.1
Fluid portion per cent by weight	36.9
	100.0

Fluid Portion	Per cent.
Vegetable oil	72.2
Volatile oil	3.8
Water	24.0
	100.00

Pigment	Per cent.
Lead calculated as white lead	13.85
Zinc oxide	34.88
Calcium carbonate	26.84
Barytes	23.10
Undetermined	1.33
	100.00

No. 49. Ruchter's Durable Paint for Building—Exterior, white, interior.

A. A. Eberson & Co., St. Louis-Baltimore.

No guarantee stated on label.

Net weight	4 lbs., 14 oz.
Capacity of can	1.06 quart
Contents	.97 quart
Pigments per cent	83.9
Fluid portion per cent	16.1
	100.0

Pigment	Per cent.
White lead	00.00
Zinc oxide	53.00
Calcium carbonate	45.90
Magnesium carbonate	1.01
Undetermined	0.09
	100.00

No. 53. Paint.

Sample sent for analysis.

Pigment	Per cent.
White lead	18.00
Zinc oxide	35.79
Barium sulphate	41.99
Iron oxide	3.18
Undetermined	1.04
	100.00

No. 55. Noxall Fast Color Paint—Outside White.

Enterprise Paint Mfg. Co., Chicago, Ill.

Unequalled for Fineness and Durability.
No. 56. Perfecto Mixed Paint—Outside White.
Enterprise Paint Mfg. Co.
No statement or guarantee given on label.

	No. 55.	No. 56.
Net weight	3 lbs., 1 oz.	0 lbs., 11.3 oz.
Capacity of can	1.06 quart.	0.34 quart
Contents	.94 quart.	0.25 quart
Pigment weight per cent	58.9	59.8
Fluid portion weight per cent	41.1.	40.2
		100.0

Fluid portion	Per cent. No. 55.	Per cent. No. 56.
Volatile oil	55.0	52.00
Volatile oil	28.0	26.0
Water	17.0	22.00
	100.00	100.00

Pigment	Per cent. No. 55.	Per cent. No. 56.
White lead	20.46	23.25
Lead sulphate	6.50	7.12
Zinc oxide	27.06	31.80
Calcium carbonate	29.23	28.44
Barium sulphate	13.64	9.18
Undetermined	3.11	.23
	100.00	100.00

Uo. 57. Favorite House Paint—Outside White.
John Masury & Son, New York and Chicago.
Label bears no guarantee.

Net weight	0 lbs., 14.3 oz.
Can capacity	0.27 quart
Contents	0.22 quart
Pigment weight per cent	54.3
Fluid portion	45.7
	100.00

Fluid Portion	Per cent.
Vegetable oil	97.9
Volatile oil	2.1
Water	0.0
	100.00

Pigment	Per cent.
White lead	00.00
Lead sulphate	4.29
Zinc oxide	60.94
Barytes	33.32
Silica	1.18
Undetermined	0.27
	100.00

No. 59. Green Seal House Paint—Outside White.
Name of manufacturer not given.
Can bears no guarantee.

No. 60. Lion Brand Mixed Paint—Outside White.
St. Paul White Lead & Oil Co., St. Paul, Minn.

"For body this paint is unequalled. Its durability guaranteed."

"When properly applied, we guarantee Lion Brand paint to give satisfaction as to covering capacity, durability and finish."

	No. 59.	No. 60.
Net weight	3 ibs., 8 oz.	7 lbs., 0 oz.
Capacity of can	1.02 quart.	2.04 quart
Contents	.95 quart.	1.94 quart.
Pigment per cent by weight	60.8	61.2
Fluid portion per cent by weight	39.2	38.8
	100.00	100.00

Fluid portion	Per cent. No. 59.	Per cent. No. 60.
Vegetable oil	91.8	92.6
Volatile oil	4.9	4.1
Water	3.3	3.3
	100.00	100.00

Pigment	Per cent. No. 59.	Per cent. No. 60.
White lead	21.53	20.65
Lead sulphate	8.03	7.76
Zinc oxide	39.13	41.27
Calcium carbonate	11.97	10.98
Barium sulphate	16.12	15.84
Silica and alumina (calculated as clay)	3.08	3.16
Undetermined	0.14	0.34
	100.00	100.00

Nos. 50 and 61 B. P. S. Paint—Outside Gloss White.
The Patterson, Sargent Co., Cleveland, Ohio.
Best Paint Sold.

	No. 50.	No. 61.
Net weight	14 oz.	3 lbs., 13 oz.
Capacity of can	0.30 quart.	1.06 quart
Contents	0.23 quart.	.99 quart
Pigment weight per cent	63.4	63.2
Fluid portion	36.6	36.8
	100.00	100.00

Vegetable oil	97.1	97.0
Volatile oil	2.0	2.0
Water	0.9	1.0
	100.00	100.00

Pigment	Per cent.	
White lead	54.61	50.52
Lead sulphate	0.00	0.00
Zinc oxide	45.09	46.06
Silica	.0.00	3.18
Undetermined	.30	0.24
	100.00	100.00

No. 62. Acme Household Paint—White.
Acme White Lead & Color Works, Detroit, Mich.

Net weight	14.9 oz.
Capacity of can	0.30 quart
Contents	0.26 quart
Pigment weight per cent	28.3
Fluid portion weight per cent	71.7
	100.00

Fluid Portion	Per cent.
Vegetable oil containing a large amount of a dissolved resin	68.6
Volatile oil	30.0
Water	1.4
	100.00

Pigment	Per cent.
Zinc oxide	99.80
Undetermined	0.20
	100.00

No. 63. Stearn's Paint—Outside White.
Made and guaranteed by Stearns Paint Mfg. Co., Davenport, Iowa.

We guarantee the Stearns Anchor Brand Paint to be made of the following material either carbonate of lead and zinc white, or such coloring and pigment as we deem necessary to produce desired shades, finely ground and tested raw linseed oil, turpentine and a very slight proportion of coach Japan and we hereby guarantee to pay $100 in gold in any case where the contrary can be proven.

Net weight	3 lbs., 15 oz.
Can	1.04 quart.
Contents	.98 quart
Pigment weight per cent	63.8
Fluid portion weight	36.2
	100.00

Fluid Portion	Per cent.
Vegetable oil	91.8
Volatile oil	5.4
Water	2.8
	100.00

Pigment	Per cent.
White lead	38.73
Lead sulphate	3.89
Zinc oxide	56.75
Undetermined	0.63
	100.00

No. 66. Tower Brand, Mixed Paint—Outside White.
Montgomery Ward & Co., Chicago, Ill.
Label bears no guarantee.

Net weight	3 lbs., 10 oz.
Capacity of can	1.03 quart
Contents	.95 quart
Pigment weight per cent	64.8
Fluid portion weight per cent	35.2
	100.00

Fluid Portion	Per cent.
Vegetable oil	84.5
Volatile oil	6.4
Water	9.1
	100.00

Pigment		Per cent.
Sublimed lead		80.28
Lead sulphate	59.09	
Lead oxide	16.01	
Zinc oxide	5.18	
Barium sulphate		19.08
Undetermined		0.64
		100.00

No. 67. Star Brand Mixed Paint—Outside White.
United States Paint Co., Chicago.
Sample bought from Montgomery, Ward & Co., Chicago.
Label bears no guarantee.

Net weight	3 lbs., 3 oz.
Capacity of can	1.05 quart
Contents	1.01 quart
Pigment weight per cent	55.4
Fluid portion weight per cent	44.6
	100.00

Fluid Portion	Per cent.
Vegetable oil	64.5
Volatile oil	17.5
Water	18.0
	100.00

Pigment	Per cent.
White lead	15.24
Lead sulphate	3.77
Zinc oxide	39.25
Barium sulphate	8.55
Calcium carbonate	28.45
Magnesium carbonate	3.15
Silica	.98
Undetermined	.61
	100.00

No. 71. House Paint—Outside White.*

Minnesota Linseed Oil & Paint Co., Minneapolis, Minn.

Strictly pure paint consisting only of pure carbonate of lead. Pure oxide of zinc, pure tinting colors.

Carefully mixed and thoroughly ground in our own pure linseed oil, pure turpentine, and pure turpentine driers.

Put up in full measure and sold subject to chemical analysis.

Net weight	8 lbs., 2 oz.
Capacity of can	2.11 quarts
Contents	2.05 quarts
Pigment weight per cent	65.4
Fluid portion weight per cent	34.6
	100.00

Fluid Portion	Per cent.
Vegetable oil	95.6
Volatile oil	4.4
Water	0.0
	100.00

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*The manufacturers inform us that this is the only grade of paint now furnished to the trade by their house, and that the paint is to be made in strict conformity with North Dakota law.

Pigment	Per cent.
Lead calculated as white lead	43.47
Zinc oxide	56.09
Undetermined	0.44
	100.00

Contents and net weights of samples analyzed calculated to gallons and pounds per gallon.

Lab. No.		Quarts	Lbs. Per Gallon	
7	Minnesota Linseed Oil & Paint Co.	....	14 lbs.	0 oz.
8	Armstrong Paint Co.	....	11 lbs.	8 oz.
9	Peoples' Paint. No manufacturer given	3.68	13 lbs.	8 oz.
36	Sherwin, Williams Co.	3.92	16 lbs.	8 oz.
38	Senour Mfg. Co.	3.84	14 lbs.	3 oz.
39	Patton Paint Co.	3.64	12 lbs.	8 oz.
40	Farwell, Ozmun, Kirk Co.	3.96	12 lbs.	0 oz.
41	T. L. Blood & Co.	3.56	13 lbs.	4 oz.
42	Bradley & Vrooman Co	3.96	12 lbs.	12 oz.
43	Heath & Milligan Mfg. Co.	4.04	16 lbs.	8 oz.
48	Seroco Paint Mfg. Co.	3.84	12 lbs.	8 oz.
49	A. A. Eberson & Co.	3.88	19 lbs.	8 oz.
55	Enterprise Paint Mfg. Co.	3.76	12 lbs.	4 oz.
56	Enterprise Paint Mfg. Co.	4.00	11 lbs.	5 oz.
57	John W. Masury & Son	3.52	14 lbs.	5 oz.
59	Green Seal, Manufacturer not given	3.80	14 lbs.	0 oz.
60	St. Paul White Lead Oil Co.	3.88	14 lbs.	0 oz.
61	Patterson, Sargent Co.	3.96	15 lbs.	4 oz.
62	Acme White Lead & Color Works	4.16	14 lbs.	14 oz.
63	Stearn's Paint Mfg. Co.	3.92	15 lbs.	12 oz.
66	Montgomery Ward & Co.	3.80	14 lbs.	8 oz.
67	United States Paint Co.	4.04	12 lbs.	12 oz.
71	Minnesota Linseed Oil, Paint Co.	4.10	16 lbs.	4 oz.

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NORTH DAKOTA AGRICULTURAL COLLEGE

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA.

Bulletin No. 68.

DEPARTMENT OF BOTANY

Henry L. Bolley and F. J. Pritchard

RUST PROBLEMS
FACTS, OBSERVATIONS AND THEORIES
POSSIBLE MEANS OF CONTROL

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

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February 1906

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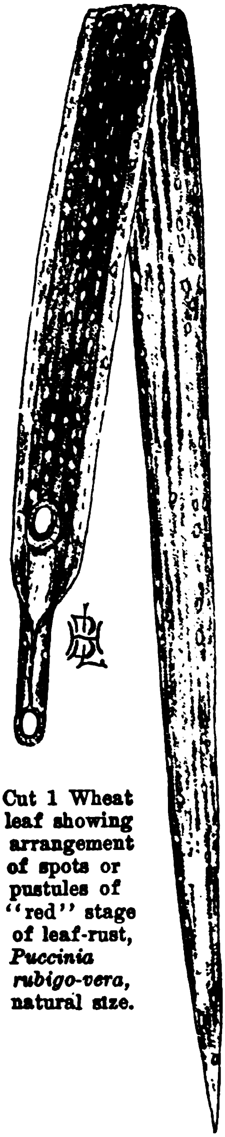
RUST PROBLEMS.

FACTS, OBSERVATIONS AND THEORIES. POSSIBLE MEANS OF CONTROL.



Cut 1 Wheat leaf showing arrangement of spots or pustules of "red" stage of leaf-rust, *Puccinia rubigo-vera*, natural size.

The aim of this bulletin is to provide the people of the spring wheat region of this country with a sort of compendium of the theories and known facts involved in the rusting of the cereals, and other important farm crops; to give the lines and results of new observations and experiments and to cite investigations and farm practices which give most promise of future success in combating or preventing crop destruction by these fungus pests. It is intended, primarily as an educational publication and, therefore discusses the doubtful, unsubstantiated and mute points of the subject as well as those phases which are more fully understood by botanists and farmers. The statements in certain paragraphs cannot, therefore, be considered as having as much weight or importance as those under certain of the more definite and detailed discussions relating to known or observed facts. For the reasons just given, it is hoped that the reader will look upon the bulletin as a source of information rather than as a guide to prevention. Knowledge concerning the features governing rust attack and crop destruction is yet too fragmentary to allow any one to give full or complete direction for attacking the rust problem on the farm, looking towards escape from the ravages of these diseases upon farm crops. Such information, as far as available, may be more clearly impressed in circulars and smaller pamphlets upon features of farm practice which affect the development of the disease.

The discussions are taken up under regular topics of the subject matter, and points of new observation and investigation are mingled with available facts and theories touching each topic. Unless the facts used have been so commonly observed and worked over as to become common knowledge, credit is given the originator of the observation or idea through the use of footnotes.

In a large part, the substance of this report is based upon observations and investigations conducted by the writer at this Experiment Station and while a student and assistant in the Indian Experiment Station. A number of the new investigations which have been planned at this Experiment Station since August, 1904, have been in part conducted and worked out as to detail by Mr. F. J. Pritchard, Assistant Botanist.

General Nature of Plant Diseases: It is but lately that it has been recognized that disease, as such, is usually due to causes which may be modified, obviated or nullified in their influence; and much more recently recognized that this feature applies with as much reason to plant life as to animal life. For ages, farmers and planters generally, have aimlessly assented to the belief that meteorological (weather) conditions account for or control all disease-like troubles of farm crops. Such belief must, so long as it prevails, prove fatal to all hope at concerted attempts at disease prevention, control, or elimination. It is true, for example, that the stinking smut of wheat (Tilletia) produces a disease of the wheat crop which is greater or less destructive in its effects according to differences in soil and atmospheric conditions involved; but we have also learned how, through inexpensive means, to circumvent its power to do harm.* It is true that the rusting of the wheat crop and allied plants is greatly influenced by weather and soil conditions; but this is not more certainly so than that yellow fever may not reasonably be expected to make inroads northward from its sub-tropic home in cold weather.

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* See original Field Experiment which introduced the use of formaldehyde in the prevention of smuts in cereals—Bulletin No. 27—1897.

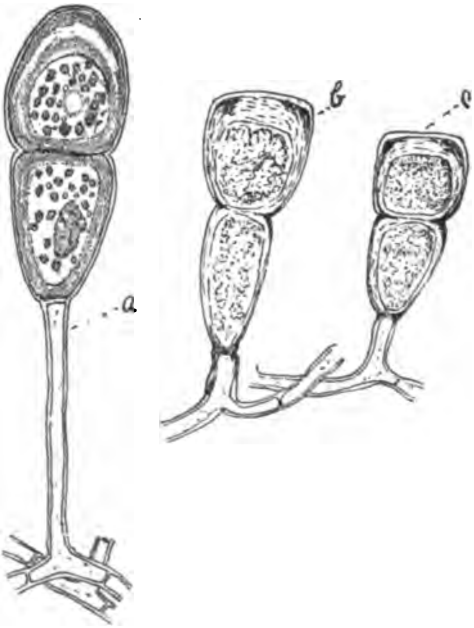
Disease may be assumed to arise from physiological variations due to variations in the normal growth factors, or may be brought about through the action of external agencies which attack, modify or destroy the organic mechanism of the plant. Physiologically, for example, plants may be sick because of improper nutrition brought about through an improper food relation. The air supply may be abnormal, as for example, charged with injurious gases. The soil may be deficient in one or more of the essential plant foods, or certain of these may be in improper proportion with relation to each other. Drainage may be so poor that roots are injured through action of a sour water supply, drowned, etc. The soil texture may be such as to cut off proper air supply to roots. The sunlight may be so cloaked or indirect that the plant may fail to do sufficient work in the manufacture of plant foods for the development of the cellular structure, etc. All such conditions and environments which bring this about may cause typical appearances of disease, or modifications in crop development which may well be called physiological troubles because they break in upon the regular working processes of plant life. One process often becomes impaired and fails because of the improper functioning of another. Such types of disease never spread from plant to plant, field to field, or place to place. They are due merely to local conditions which are not transmissable.

Infectious Plant Diseases: There are yet other types of diseases which are properly designated as infectious diseases, which arise through the action of living organisms, and hence may be transmitted from plant to plant, field to field, and from the crop of one region to that of another in any manner in which the organisms can be carried. The organisms which produce or occasion such infectious troubles among plants are usually plants and are always quite minute. They live as parasites, drawing their nourishment from the host and spread or propagate through the production of countless numbers of minute, usually quite invisible spore bodies which perform for these disease producers the same function performed by seeds in higher plant life.

Since these minute disease producers are living beings, one can understand why the weather, food, conditions, and stage of plant or crop development should so largely effect their multiplication and powers to do damage. It is a well known fact that plants of a particular kind need special conditions for growth and distribution, and that it is almost impossible to acclimatize them; that is, to fit them to a marked change in the natural conditions or environments except through a mode of persistent, intelligent selection acting through a long period of time. Such selection, in fact is but a type of natural selection. (See page 663.) So it is with the organisms which produce infectious diseases. Each kind, after ages of gradual evolution, through natural survival, has come to fit into the special growth conditions which quite commonly surround the host, the plants or crops, which it attacks, or which are produced by the tissues of that host under the prevailing conditions of air, soil and water. The special conditions referred to may be such as to directly affect the life functions of the host, or as may directly increase the powers of the parasite itself, or both associated. Thus, for example, most fungi which produce disease, grow rapidly in the comparative absence of direct light. While some do well under rather dry conditions, most of them demand an atmosphere approaching the stage of saturation. Again, many fungi and bacteria need oxygen, as do other plants, but thrive best when it is so far reduced in the atmosphere that the life processes of green plants become almost impossible.

Those who wish to understand the strange and often misleading features in the development of infectious diseases in farm crops must hold such facts and possibilities in mind.

The Nature of Fungi: To the general reader, the term fungus, (plural, fungi) does not convey a very comprehensive idea of the type of plant it represents, or of the rapidity with which such plants may multiply and become distributed through natural means. This, in part, accounts for the difficulty most persons have in appreciating the power possessed by such organisms. The idea of fungus is usually associated with such form as the mushroom or puffball, but such represent only the more noticable types.



Cut 2. Drawings of typical shaped resting spores of the two chief species of rust fungi which produces the rust disease in wheat, showing the comparative size and shape of the spores of the two species. *a*. Teleutospore of *Puccinia graminis; b*. and *c*. Teleutospores of *Puccinia rubigo-vera.* Notice the thickened walls of the spores which allow them to resist harsh weather conditions, also the shape of the filaments from which they arise. The magnification is approximately 800 diameters. Original.

Most fungi are much more minute. However, all approach the filamentous form or growth seen in ordinary mushroom spawn. These filaments draw nourishment from the substance, soil or plant upon or in which they grow. Some of these fungi live upon dead substances and produce decay upon such substances as fruit, cheese, bread, meat, wood, humus of the soil, straw, manures, etc. Such fungi as the bread mould and the mushroom types are good examples of such as are called decay fungi (*saprophytes.*) Those which grow only upon living things drawing their food from the living juices of their hosts are called *parasites.* As examples of such the wheat smuts and rusts are amongst the the most perfect types. It is probable that the rusts pass their whole developmental life upon living organisms. They are thus amongst the most perfect types of parasites known, but it is possible that, as in the case of the smuts, there may be stages of spore multiplication which are of a saprophytic character.

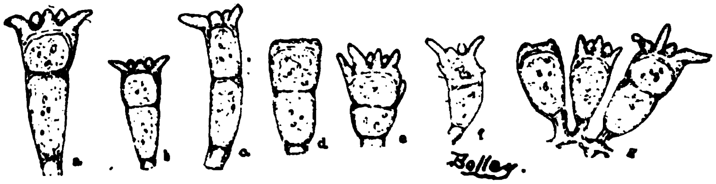
Fungi seldom produce any definite bodies except when they prepare to develop the reproductive spores. The true body of a fungus consists of the fine filaments or threads which permeate the soil, the substance or the living tissues upon which it thrives. The reproductive bodies are caled spores and are simply small bits of the body filaments or threads modified in a special manner. The spores are cut off from the threads at such special places and in such manner that they may be readily scattered by the natural agencies of wind and water, insects or other suitable agencies. Some fungi produce several types or forms of spores, enabling them to take advantage of numerous natural conditions for dvelopment and distribution. Most spores are quite resistant or tenacious of life, but some sorts are quite delicate. In the last named case, they are usually produced in countless unmbers.

Distribution of Rusts and Losses Occasioned: The rust diseases are cosmopolitan with the distribution of the crop attacked or its native host plants. There are one or more rust diseases for almost every cultivated crop and for many garden vegetables and for most trees and shrubs. The cereal grains are destructively attacked in almost every country in which such crops may be grown without irrigation, and the native grasses are especially open to attack. We sometimes exaggerate by statements which indicate that cultivated crops suffer more severely than native relatives and associates. This is hardly the truth. It is probable that one only thinks so because more interested in the cultivated forms, and because the cultivated plants are often given such abnormal growth conditions to contend with that the rusts easily complete the destruction otherwise begun. It is, in fact, a matter of common observation to find native wild plants and herbs almost destroyed by the rusts which attack them. A study of such cases usually reveals the fact that the most severely attacked plants are under conditions and environments differing from those which are characteristic for such native growths. While it is true that the rusts attack their host when under normal growth conditions, the facts just noted indicate that crop damage by rusts is affected greatly by conditions. The fact, however, that the conditions which tend toward luxuriant succulent crop growth, are just such as tend to favor rust spread and development, in a large way account for the difficulties met with in attempts at controlling rust action.

It is not necessary, at this time, to enter largely into a discussion of the losses occasioned to agricultural interests. The havoc wrought in the great wheat field of Texas and the Dakotas is too recent to need recounting. These diseases destroy the beauty of many garden flowers, disfigure vegetables, defoliate shade trees and ornamental shrubs, and cut down the yield and quality of all field, fruit and garden crops. But above all these, the loss occasioned in the cereal grain fields is so pronounced that farmers, when rusts are mentioned, think only of such crops as wheat, oats, barley, etc. It is impossible to secure statistics which give an adequate estimate of the losses occasioned to the grain producing districts of the world. Destructive invasions of rust follow so closely upon varying conditions of climatic environment that there is no regularity of recurrence. For this reason, perhaps, statistics of a reliable character are not compiled. It is quite sufficient to recall the fact that each year great areas in the cereal producing states suffer partial to nearly complete loss. Indeed, it is not uncommon for some of our great wheat states to suffer damage equal to fifty percent of the average annual crop in yield and grade.

It is easy for one to think that the region in which he lives is the only one subject to such fierce devastation. This is certainly not true of rusts. These diseases respect no country save only those in which no dews set or rain falls, and they are not "something new" as many farmers complain. These same troubles are recorded as destructive to crops by earliest writers. One of the commonest species *Puccinia Rubigo-vera,* is the name-sake of an old Roman deity. See also a note by Shakespeare, King Lear III-4 "The foul fiend 'Flibbertigibbet' mildews the white wheat ." "Mildew" is the confusing term by which most English writers designate the stem-rust of wheat, *Puccinia graminis.*

The Australian and Russian fields suffer immense annual losses; and in England where the annual average yield, because of high culture, often approproximates thirty to forty bushels per acre, in years of rust epidemic, the crop, at times, falls to fifteen and twenty bushels of inferior value. It is indeed one of the chief reasons why Japan, China and other moist warm countries are unable to successfully produce the wheat crop. No country which produces wheat, rye, oats, barley, and flax is free from yearly damage or from occasional visitations of extensive crop destruction. An irregularity of invasion is characteristic of these diseases, here light in effects, there total destruction. Few farmers will assume that the annual loss in the wheat states of this country is less than one hundredth of the crop. Assuming that the annual yield for the United States is approximately 600,000,000 bushels valued at seventy-five cents per bushel, the annual loss thus indicated would be $4,500,000. Assuman annual crop in North Dakota of 60,000,000 bushels, the loss estimated at one per cent. to the farmers of the state would represent $450,000 annually. In fact it is trivial to speak of the loss as only one per cent. I have examined the fields over this state for fourteen seasons, and each year the injury to the foliage of the crop has been such in all of the damper regions of the state that I think the average annual damage to the crop, aside from the years of great destruction, approached closely to ten per cent. of the actual prospects. For the season of 1905, various crop experts placed the loss to the wheat crop of the Northwestern wheat states, Minnesota and the Dakotas, at 30,000,000 bushels, aside from the losses in grade. The losses in 1904 were even greater. It seems quite within a reasonable guess that the average annual loss to the wheat crop of the United States alone approximates fifteen to twenty millions of dollars.



Cut 3. This shows a number of characteristic forms of resting spores, teleutospores, produced by *Puccinia coronata*, the orange leaf-rust of oats. This rust is sometimes called the crown rust because of the peculiar points upon the resting spores. Magnification approximately 350 diameters.

As the rust diseases are occasioned by a type of fungi of such minute form that the spores may be wafted great distances by wind currents, carried by water, or distributed even by minute insects, and, as we have been able to demonstrate that the various spores are quite resistant to atmospheric conditions and to summer and winter weathering, it is easy to account for the almost universal distribution of the diseases. The spores may be taken as essentially ever present and thus the coming of the disease in a crop depends essentially upon circumstances of weather and crop development.

That no more systematic and co-operative attempts have been made by agriculturalists to control the rust diseases of farm crops, does not seem strange in the light of the peculiar nature of the causes, their intimate parasitism, and the ease with which they are transmitted. Furthermore educational methods in our schools have not been such as to train people to see minute affairs or to think very connectedly about them. Farmers, especially, are not given to thinking over much about disease and disease breeding conditions. Very much real indifference is due to long standing, close, but imperfect acquaintance with such diseases.

The peasants of Russia, and similar unenlightened peoples look upon rust invasions as but "visitations," sent by God to add to the evil times in which they live; and many of our own people, qite as easily, and with no more reason, convince themselves that "nothing can be done" for it is "all a matter of weather." Yet others with more knowledge of the actual facts, forgetting, for it is easy not to act, all that sanitary cleanliness has done in preventing infectious diseases in man and animals, and forgetting the triumphs of science in other lines, calmly say that the problem is too difficult, "you will have to show an easy road." However there are others with faith and works.

It seems quite within probability that farmers may in the future, acting along lines which correspond to sanitary methods practiced in guarding against diseases of men and domestic animals, and through putting into action breeding principles similar to those which are well understood by animal husbandry men, produce such results that such destructive rust invasions as have lately devastated the wheat fields of the Northwest and the asparagus beds of the eastern states may not occur.

The rust parasites are many sided in their natures. They have many means of perpetuating their kind, of attacking the crop, and many conditions of soil and of air, which influnce them in their powers of producing damage. For these reasons, it may not be expected that the rust problem can be done away with through some single, simple process, as was the case in our discovery of the formaldehyde method of smut prevention.

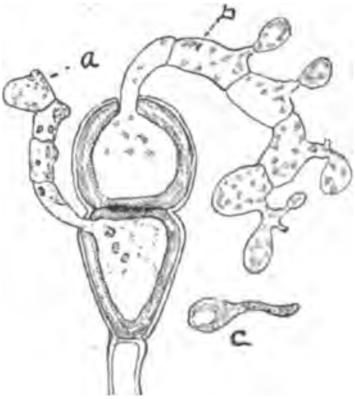
We must resort to general education of all farmers, our neighbors and our neighbor's neighbors, so that there may be uniformity of action along the essential lines of prevention. We may as well, one time as another, give up the idea of a radical cure, such as that which might be involved in the principle of spraying, seed treatment, special methods of cultivation, fertilization, crop rotation, etc. We may need to use a combination of all of these, and more, but the rust diseases are well enough known, as to their means of attack, to exclude the possible efficiency of any one such preventive method.

CAUSE:—There are many peculiar, indefinite, and erroneous beliefs among farmers and gardeners regarding the primary cause of rust. Thus, regarding the rusting of cereals, many have ready replies to the question of cause. One often hears; "It is due to soil depletion;" "too continuous cropping to one crop;" "rotting of the straw by damp, foggy weather;" "wet occasions too great a flow of sap bursting the stems and then the scalding sun does the rest." And many more such which cannot stand the test of reason, and the eye aided by the microscope. Let it be distinctly understood that the direct cause is well worked out. The rust spots on the stems and leaves are masses of the fruiting parts of definite plants which live upon the diseased plants.

Rust on grain is caused by distinct plant parasites, fungi. The parasitic plant which causes rust is microscopic in size, and grows from spores, small seed-like structures. It is masses of these spores which form the pustules or rust spots, red, brown or black, seen en masse on the leaves, sheaths, and stems of the grain. There are two distinct species of rust which attack wheat, both of which produce first, red spores, which make the red spots, and, later on, produce the black spores which turn those spots a black color. There is thus no such thing as red rust and black rust, but rather the black rust is only an advanced stage of the red which precedes.

It may be said that each cereal crop has its own type or species of rust parasites which attack it. Each disease producing rust fungus needs special conditions for its development which vary with the crop. Wheat, so far as is now known, is attacked by but two important rusts: *Puccinia rubigo-vera,* the early, orange leaf-rust, and *Puccinia graminis,* the late, stem-rust. Farmers some times use the term "red" to indicate the first named rust, and the term "black" for the second named. This is confusing, for both species produce first reddish spores then black ones. The early orange leaf-rust produces rounded orange colored spore beds or spots, coming early and over the entire upper surface of the leaves and outer surfaces of the sheaths and stems. The black spores of this rust appear about ten days later as small black, fly-speck-like, rounded spots under the skin surface but not commonly in the old orange spore beds. The late stem-rust grows either on the leaves, sheaths, or stems, if these are green and succulent when its spores are being distributed. Usually the early orange leaf-rust has come previously and destroyed or dried up the leaves and lower sheaths, leaving only the upper sheaths, neck and head part for the attack of the late stem rust. This stem rust at first forms long or ovid brick-red to brownish red lines or confluent spots in the skin of the wheat plant, actually rupturing or tearing open the skin large enough to show the naked eye the raised torn skin(epidermis.) Whenever it appears upon the leaves, one spot often breaks through on both sides. Two weeks later, these same brick-red spots gradually turn darker, becoming black. The summer or brick-red spores fall off or blow away and new black or winter spores push up through the same opening in the skin. This accounts for the change in color. These differences will allow any one by a little observation to recognize the two kinds of wheat rust.

The method of rust attack and rust growth as seen in wheat is characteristic, though there are many modifications to be noted in different crops. In wheat, red rust spores form first in countless numbers and blow about in the slightest breeze. If one falls upon a wheat leaf or lodges against a rough place on a wheat stalk, it remains in a resting condition until a light rain or slight dew furnishes a film of moisture upon the wheat, when it germinates at once, sending out a small thread or filament. This filament bores its way into the stem or leaf. The time necssary is but an hour or two. Hundreds of such spores may often be counted in an ordinary dew drop, having fallen there from the air as dust from other affected plants. It takes from nine to thirteen-days for the rust to break out as a spot or pustule, after the germination of an infecting spore. One can tell whether the wheat plant is in-powder, which is made up of spores, breaks through the surface of the plant. By examining the green straws or leaves



Cut 4. Sketch of a germinating Teleutospore, resting spore, of *Puccinia graminis*, the stem-rust of wheat, showing the peculiar short filaments which arise from these spores in the spring and the mode in which a number of small spores, *sporidia*, are cut off. It is these sporidia which infect the barberry bushes. Magnification is approximately 800 diameters. Original.

closely there may be seen slight translucent or lemon yellow spots over much of the surface. Each such spot represents a point of infection, where a rust spore has germinated and the filament has gone in. These spots may be best observed by holding an infected leaf or split piece of a green stem between the eye and the light.

Since the cause of rust diseases are plants having the peculiar needs and characteristics of plants, it becomes necessary that we should understand each species quite intimately, learn its full life history, its habits and needs and its effect upon the crop. In this manner, it may be hoped that intelligent methods may eventually lessen the ravages of the diseases.

Differences as to Species and as to Spore Forms: At the outset it may be well to call attention to the facts that in cereals there is one or more rusts for each crop and that certain ones of the rusts are common to several of the cereals and may also attack a number of other grasses. It is also a feature of the rust fungi that they use several means of reproducing their kind, usually forming several different types of spores, each sort serving to propagate and distribute the disease producing fungus in a different manner and under differing conditions as to time and crop development.

The Rusts of Cereals: It is a common error with many persons to assume that all rust is of one cause, no matter upon what plants found. Thus in the spring of 1905, the writer called attention to the abundance of the stem-rust fungus of wheat upon the local barberry bushes, noting that it was not only more abundant but earlier than usual in maturing, and thus liable to induce a heavy infection of this disease upon the wheat crop, should favorable weather intervene. This was much ridiculed by some writers who said: "rust can be found upon any old shrub or weed." Certain stock exchange gamblers, interested in deceiving the people, remarked through the press that "barbed wire fence is also subject to this disease." Others, taking the matter more seriously, at once forwarded many samples of weeds and shrubs attacked by particular rust parasites, including the common rust of rose bushes, thinking, perhaps, that one had "escaped the notice of the scientists." However, most such rusts are quite well known as to their life histories; and it is known that the rust parasites are specialized quite narrowly to live upon single kinds or nearly related species of plants. Thus the cotton-wood leaf rust is not known to grow upon other than cotton-woods and willows. The rust of rose bushes, *Phragmidium,* is of a very specialized form and is not known to be able to attack other than the true rose bushes. The destructive rust of asparagus *Puccinia asparagi* apparently runs its full life course upon the asparagus plant. The rust which attacks flax *Melampsori lini* also seems quite closely confined to that host. And even the peculiar rusts of cereals which attack more than one species of grain and grasses as well as other herbs and shrubs have marked preferences and confine themselves naturally to a quite limited range of hosts. True, each produces several spore forms and there are many possible unknown points of life history; but in all cass yet studied the structural features of difference are always sufficiently well marked to allow the microscopist to recognize and separate the different species.

A confusing feature of the cereal rusts is due to the fact that they commonly produce their spring or earliest set of spores, the sexual stage, upon some non grass-like plant, some herb or shrub. An imperfect knowledge regarding this feature of the life of the stem-rust of wheat, perhaps, accounts, in part, for the common belief among farmers that not the barberry bush alone but many other shrubs may be guilty of harboring and developing the spores of this dread pest. Let it be said at this time that botanists have labored long and persistently but have, as yet, found no other herb or shrub upon which the spring spores of this rust *Puccinia graminis,* will develop. The same feature studied for other types of rusts which thus attack hosts of a diverse nature seems to show that the spring stage, cluster cup or sexual stage of spore formation, is commonly confined in its attack to but a single species or to but a few of very closely similar characters. Thus the rust of corn *Puccinia Sorghi* has its spring stage upon a common, yellow Oxalis, sorrel, and the cedar-apple producing rust,*Gymnosporangium,* produces its spring or sexual stage upon the apple and closely allied plants, causing the so-called apple-leaf rust. We may, therefore, dismiss the thought that there is no hope of controlling the cereal rusts because their sexual spore stage has too wide a range of host plants. The hosts for this stage will probably be found to be few and unimportant for any one of the cereal rusts.

Many people also become confused because the cereal rusts produce two or more sets of differently formed spores on the crop. It is for this reason that the confusing terms "red rust" and "black rust" of wheat are quoted. Farmers also get confused in estimating the probability of rust injury to their wheat or oat crop because two or more different species of rust parasites may attack one and the same crop. Thus, for wheat in the northwestern states two species are always sure to be present in greater or less destructive force, *Puccinia rubigo-vera,* the early, orange-leaf rust, and *Puccinia graminis,* the late or stem-rust. *Oats* are generally attacked by the early, lemon yellow, leaf-rust, called *Puccinia coronifera,* because of the crown-topped spores, and also by a strain of *Puccinia graminis. Rye* is attacked by *Puccinia graminis,* causing stem-rust, and by a special strain of *Puccinia rubigo-vera,* causing leaf-rust. *Barley* is attacked by a special strain of the leaf-rust, *Puccinia rubigo-vera* and by the same strain of *Puccinia graminis* that causes stem-rust of wheat. Modified or form species of these three species of fungi also attack various grasses.

Gradually it is becoming known, through numerous inoculation experiments that the spread of these kinds of rusts from one grass or grain crop to another is probably even more restricted than once supposed. While, for example, it is possible to infect either wheat, oats, barley, or rye with rust spores grown on the barberry leaves, there are strains of this rust (form species) for each grass or grain, which attack that crop more easily than any other of the group. Thus, it was found in our tests, that we could infect barley easily from the spores from a certain barberry hedge and that these would also attack wheat, but much less readily. In the case of the orange leaf-rust, this specialization of the species into form species has become much more definitely fixed than in the case of the stem-rust, *Puccinia graminis.* These points indicating specialization into form types have been proved by extended inoculation tests made at different times and places by different investigators including Arthur, Kellerman, Carleton[*] and Erickson.

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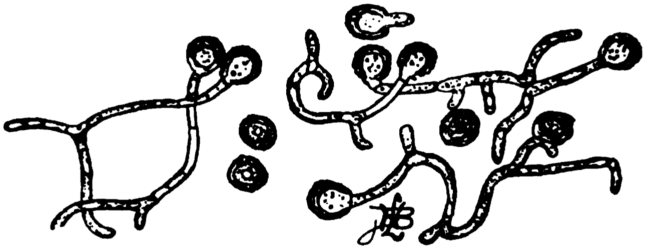
[*] For a rather full explanation of experiments of this nature, see M. A. Carleton in Bulletin No. 63—U. S. Department of Agriculture, Bureau of Plant Industry.

Life Histories of Rust: In speaking of higher form of plants and animals, we term all those life phases and periods from the time of its inception to maturity, its life history. Biologists make much of the facts of life histories in determining fundamentals of character and of relationships. Botanists have found much use for such facts when studying the lower types of plant life, especially of those fungi and bacteria which produce diseases. It is a characteristic of many fungi that in the development of the individual there may be two or more rest periods in the completion of a life cycle or history. The beginning of each separate stage in a cycle is always some type of spore formation. Usually the different types of spores which are found in a particular life history are so different in form and character as to excite no idea of relationship. And often their modes of development and habits of after growth are so divergent as to entirely mislead the investigator, leaving the complete life cycle unknown as is yet the case with many of the rust fungi and other parasites which occasion disease. Only complete cycles are known for those upon which many investigators have labored extensively. It is said that the "life history" of a fungus is known when one can start with one spore form and through inoculation and culture experiments develop one spore form from another until a return is made in the life cycle to the



Cut 5. Sketch of a number of Uredospores, summer or "red" spores of the leaf-rust, *Puccinia rubigo-vera*, showing germination processes or tubes. It is these tubes which penetrate the surfaces of the wheat plant. See Cuts 6 & 7.

form with which the experiments started. This has been done for many rusts as, for example, *Puccinia graminis,* the stem-rust of wheat, *Puccinia rubigo-vera,* the orange leaf-rust of wheat and for *Puccinia coronata,* the leaf-rust of oats.

In investigating the life histories of these and other rusts of grasses and cereals, botanists have, from the first, assumed that the spring stage or *aecidium* stage should be the natural birth or beginning of the life history of an individual rust plant. The assumption was probably due to the belief held by many, as probable, that the aecidium stage represented a depressed sexual stage. Consequently the different forms assumed by the plant body of the rust in its life history, including the peculiar spore forms and the apparent necessity of a change of hosts (see page 623) are to be looked upon as essential stages or periods in the development of the individual. An ordinary wheat plant shows all of the phases of its life development in the parts of one body, but a rust plant upon it can never complete its full life cycle as a single body, but is represented by several stages or periods of development and arrested growth and by numerous separate branches widely distributed in space and time. To make clear, the development of the full rust plant is, in a way, more analogous to the annual life of a potato plant which is spread all over a continent through seeds, and through cuttings made from tubers and distributed by man, each hill from a cutting being looked upon as but a development from a bud or branch of its particular mother plant while each hill from an individual seed is to be looked upon as the beginning of a new individual growth. So with the heteroecious rusts, all essential evidence now points to the aecidium stage as the origin of new rust individuals.* It is characteristic of science that features of theoretical existence must not be assumed as facts until actually found or observed. Gradually the sexual process is being demonstrated for many of the indefinite types of fungi and there are some strong arguments for sexuality in the rusts.* This is no proof, however, that there will not be exceptions to the rule in many orders. There are even species of the higher plants, for example, which have apparently been able to do away with the costly process of sex production. In a thesis,** June, 1889, the writer called attention to sex process as being possible through fusion of the filaments (*hyphae*) of different individuals. Also to the possibility that in certain cases of parasitism the nutritive needs of the parasite may be so efficiently met by the different host plants that the sex process, for this reason, might no longer be maintained. "So far as is known, the sexual process is chiefly one for re-invigoration, that the life of the species may be continued unimpaired. While in the great majodity of plants this is accomplished by the formation of a new plant body by the union of two more or less specialized masses of protoplasm, constituting the sexual process, it seems that some, because of certain favored conditions, are able to do away with this special method, being able to draw sufficient nourishment from their more excellent food supply. In the parasite the source of energy is the nourishment obtained from the host, and the better the connection between the parasite and its host the less liable is the protoplasm of the former to suffer vitiation for want of nutriment matter."

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*DeBary, in Die Brandpilze, 1853, directed attention to this line of thought, but it is only lately that anything like definite proof has been offered, though all circumstantial features of rust histories point that way.

"In the Uredineae, rusts, the union of the host and parasite is almost perfect, and in those species in which the whole development is upon one host it is probable that the wants of the fungus are adequately met. That some species are heteroecious upon particular but diverse host species is, we think, but indicative of the fact that the combination best complies with the nutritive needs of the parasite not to be fulfilled by one host alone."

If the actual sexual process can be proved for the rust

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* See Blackman "On the Fertilization, Altenation of Generations, and General Cytology of the Uredineae" in Annals of Botany, XVIII, p—321—1904.

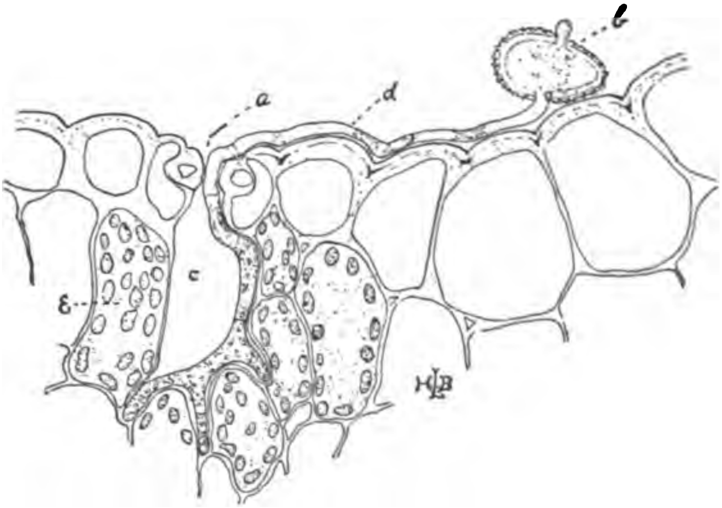
Also—Christman on "Sexual Reproduction of the Rusts" in Botanical Gazette XXXIX—No. 4, p—241.

**The Heteroecismal Puccinia, American Microscopical Journal, Vol. 10, page 168—180.

Puccinia graminis, its peculiar relationship to the barberry shrub and its various forms, hosts would, in part, be explained by the fact, but the above theories of cellular and hyphal fusion would still, I think, stand as accounting for many peculiar variations in virulence which this and similar species of rust at times exhibit upon change of hosts, and change of conditions under which the host plants are grown.

The Spore Forms: The rusts which attack grasses and grains are all supposed to produce in order, from spring to spring, the following form of spores: aecidiospores, uredospores, teleutospores and sporidia. These different spores are well known in the case of many of the common rusts of grasses, including those of wheat, oats and corn. The term aecidiospore is formed from two Greek words meaning injury and seed. These spores are formed earliest in the year and, in the case of rusts of grasses, are formed on some shrub, or herbs other than grasses. The uredospores, (blight spores) are produced in the early summer, and are often called "summer" spores. They are the "red" spores which produce the intense blighting of the leaves of the host plants as, for example, in the leaf rusting of the wheat crop. The teleutospores (completion spores,) as the term indicates, are the final spores of the season. They are often called "resting spores," "winter spores," etc., because in most cases, it is found that they germinate most freely after wintering. These are of darker color in the wheat rusts and, in mass, form dark lines, pustules, or spots: hence the origin of the common expression "black rust," for *Puccinia graminis* in which the pustules, spore masses are quite brown or black. The term sporidia is applied to numerous very minute, very delicate little spore bodies which are formed on the germination tubes or filaments which are produced by the winter spores at germinatin. See cut 4, fig. c, page 619. It is these small spores which are supposed to infect the host plant which bears the aecidium stage.

Life History of the Stem-Rust of Wheat: *Puccinia graminis*: As indicated in the matter of life histories, while some of the rusts produce all of the spore forms upon one single sort of host plants, others use different types of such hosts upon which to complete the full life cycle. The asparagus rust is a good example of a rust parasite which is able to spend its entire life upon a single host, and the stem-rust of wheat is a good type of the sort which makes use of several types, genera, and species of host plants upon which to develop its different types of spores. An outline of the lines of development for this rust is of most importance for the purposes of this bulletin and will be sufficient to illustrate the full meaning of life history as applied to rust fungi.



Cut 6. A drawing of the cellular structure of a small portion of a cross section of a wheat leaf showing a "red" spore of *Puccinia graminis* germinating and sending its branching filaments into the air cavity of the leaf through the breathing pore. *a*. The breathing pore or stomatic opening of the leaf. *b*. The germinating spore. *c*. An air cavity of the leaf surrounded by cells containing leaf green. The magnification is approximately 350 diameters.

Starting with the well known black spots or pustules which form upon the wheat straws late in the summer season, one finds that an examination reveals that each of these spots is due to an injured or ruptured spot in the surface of the straw; and that the cause is due to the formation of countless numbers of Indian club shaped, thick walled spore bodies which arise from the interior. See fig. a cut 2. These are the winter or resting spores, teleutospores of this rust. The number of such spores in a single spot is often quite numerous. We have found a spot one sixteenth of an inch long and one fortyeighth inch wide contained 2,302 spores.

It will readily be seen that the number formed within the pustules of a single rusted straw is beyond ordinary count. These spores do not germinate the same season that they are formed, at least, no one has yet been able to find a germinated one until late the following winter. The writer has often stored them under normal wintering conditions. Numerous trials of these made by myself and by students have failed to give germination results until the late winter and spring months. It is possible that carefully planned experiments may yet give different results; but natural features would seem to suggest that the rest period may always be expected to occur.

These resting spores are commonly two-celled, and thus when they sprout there is usually a germ tube (pro-mycelium) from each cell. These germ tubes are commonly not extended into long filaments but divide into four cells which at once give rise to several small but delicate cells, called *sporidia*. This greatly increases the number of spores; and it is these minute affairs from which we next hear in the line of rust producers. These may germinate at once, indeed, if in water, they begin immediately to send out fine ramifying filaments or tubes, (see fig. c cut 4). I have observed that countless millions of these bodies may be found in early spring months upon almost any mass of damp decaying rusty straw. The same has also been discovered for oat rust, corn rust, rust on barley straw, rye straw and for the rusts of many other plants and grasses. It is thus a proven fact that it is the nature of the winter or black spores to follow this course of secondary spore formation during the spring months. The ground and surface waters of an old wheat stubble field may thus be quite swarming with them and clouds of them may be wafted about by the winds. They stand but slight drying, but sufficient to allow them to be blown to quite distant points without injury, should they chance to fall into moisture.

Botanists do not know what numerous uses these sporidia may serve in the economy of the rust plant. It has often been thought that they might infect the wheat plant directly by way of root, leaf or other surface, but of the numerous experimenters, none has reported success in artificial trials. The winter has sprayed wheat plants of all ages and filled the soil of wheat culture beds full of such spores without successful infection of the wheat. One fact is agreed upon. It has been found that these sporidia from the resting spores of the various cereal and grass rust can infect certain shrubs and herbs, and thus bring about the spring stage (aecidium stage) of rust. But few of these spring host plants have as yet been found. At least, one each have been found for the most important rusts of grains. For example, the rust of corn in this stage attacks *Oxalis cymosa*, * a common yellow wood sorrel. The stem-rust of wheat, *Puccinia graminis*, produces its aecidium on the leaves and fruit of the barberry bush, see cut 15. Numerous experimentors in various countries of the world have verified this fact. The author has done so many different times in different years.** The filaments from the sporidia bore through the skin surface of the leaves of the barberry or pass inward through the breathing powers. In a few days numerous branching filaments ramify the tissues of the barberry beneath the point of infection and early begin the formation of a new set of spores, see cut 16, which are cut off in chains and in countless numbers from each infection spot, rupturing the skin of the host plant so as to form peculiar little cups and clusters of cups, full of yellow spores; hence the common name, "cluster cup stage" sometimes applied. These spores will germinate at once if they fall into a dewdrop or other water, forming a long, fine tube or filamentous thread. When these spores are placed or fall in contact with the green leaves or sheaths or stems of a living wheat plant which is sufficiently damp to moisten and hold them in place for a few hours, an infection spot is formed which runs a similar course in the tissues of the wheat plant to that described for the barberry infection, then breaks out as a spot of summer rust or "red" rust of wheat. The spores form in such great numbers that the skin of the wheat plant is split open at each point of spore formation thus allowing the spores to drop off and be blown about from plant to plant. These "red" spores *uredospores,* in turn may germinate at once, if moisture is present, and the tube which each forms may bore its way through the skin of a wheat plant and thus start another point of infection, which in turn produces other red spores. As several sets, generations, of such red spores may be produced during the growing season, the whole results in countless miriads of spores; and accounts for the gradual spread of the disease and increase in rustiness from day to day as the crop develops. A count of these spores for one generation in one pustule 1-16 by 1-64 inch in size showed over 3, 000 such spores per spot. Finally these same spore beds in which the red spores first formed begin to produce the black, thick-walled, Indian club-shaped, two-celled resting spores, teleutospores. These latter spores may also arise in new spore beds in which no "red" spores have first formed.

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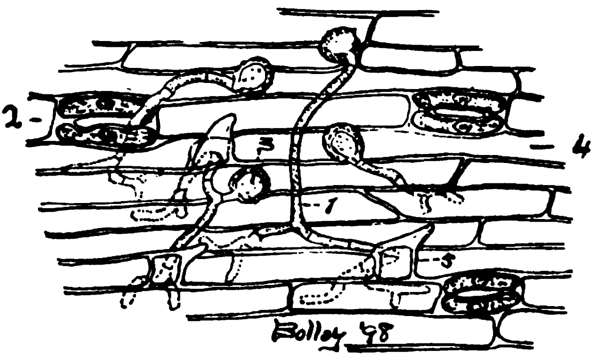
*Arthur "Cultures of Uredineae in 1904," See Journal of Mycology Vol. II, No. 76 p—50.

**DeBary a German Biologist of note, first gave a clear demonstration of these facts as early as 1853. Die Brandpilze and other publications.

The single threads or branching filaments of the rust body which ramify the cellular structure of the barberry or wheat plant and finally cut off or form the different spore bodies are called *hyphae,* (fungus threads) and the entire branching mass of filaments is commonly spoken of as the *mycelium* or body of the fungus.

Mute Points in the Life History of the Stem-Rust of Wheat, *Puccinia graminis*: We have been able to advise how to prevent such diseases as stinking smut of wheat and many types of fruit and vine diseases because knowing accurately the life histories, we have been able to select some point which is open to treatment, but the mode of attack and means of distribution enjoyed by the wheat rust fungi seem to leave no opening for treatment such as is presented by stinking smut. Yet, so long as there are points in the life histories of the rusts which are not clearly understood, there is hope. Botanists know many definite things about *Puccinia graminis*, yet I doubt if any will contend that he knows all of the sidelines of that fungus life which makes it possible for it to be so generally destructive at times and so generally ineffective in other seasons. Under the last heading the main facts of the life history of that rust are outined. There are other important features which are not so clearly known. Among these mute points the following are typical features for discussion and study: (1) How many grass plants beside wheat may certainly be attacked by this fungus? (2) How many such grasses may bear spores of the rust which are able to carry the disease to wheat? (3) How many species of grasses produce resting spores (teleutospores) which may infect the barberry shrubs? (4) Are the barberry shrubs the bridging hosts for all? That is, after transmission to the barberry, may the spores then formed attack any grass of the series of hosts for *Puccinia. graminis*,. or are they confined exclusively to the grass host



Cut 7. A sketch representing a number of uredospores, summer or "red" spores of *Puccinia rubigo-vera*, germinating upon the surface of a wheat leaf. The drawing illustrates how the filaments sometimes pass through the opening of the breathing pores as at "2," and sometimes directly through the leaf as at "3" or "5."

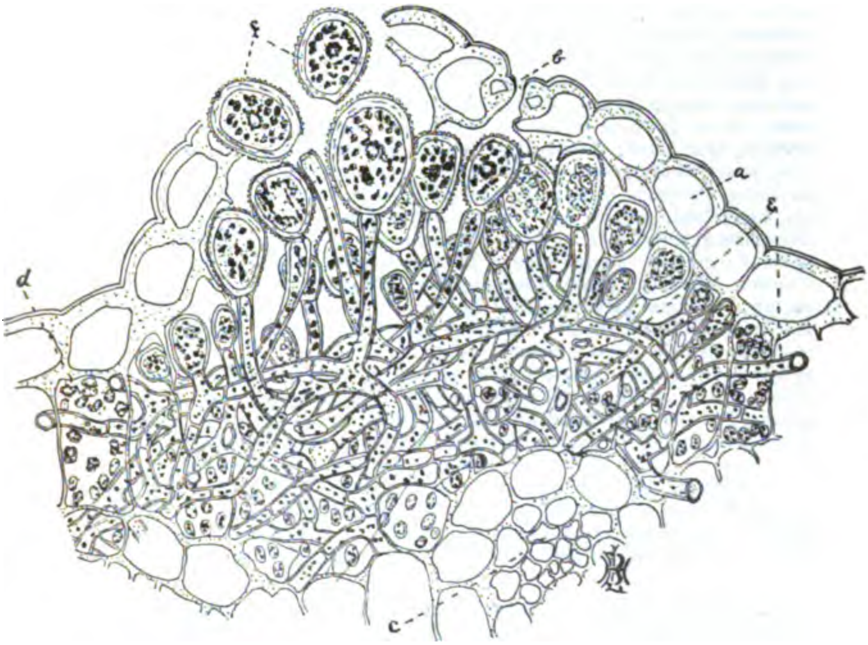
which produced the teleuto form of spores? (5) Are the allied barberries the only aecidial hosts for this stem-rust? (6) Is the aecidium stage essential to the continued existence of this rust? That is, will the rust lose its vitality and pass away if it is prevented from forming this stage of its present known life history? (7) May the germinating teleutospores, or any secondary, tertiary, or other continuation form, which arises from that spore, introduce the disease directly to wheat or other grass plants? (8) The aecidial stage produces beside the regular yellow spores, extremely minute spore bodies, called spermatia. Of what, if any, life purpose do they fulfill for the rust? (9) Can the disease in any stage be transmitted by broken particles of mycelium in any condition, dried or otherwise? (10) Does the mycelium ever persist from season to season? (11) Do other spores than the teleuto form ever persist form seaseason to season? (12) Can the disease be perpetual by one stage alone?

Other such questions might be added to this list, but some may say that some of these overlap. This is true and clear answers to certain of them might answer all. Even then a practical method of preventing the occurrence of rust might not be forth coming.

Many facts are already known touching upon these questions, but much is yet only theory and there are a great mass of unknon features connected with each. It is evident that there is yet room for much experimental work to be applied along these lines. To be of use it must be, of the most exacting sort and then all must be properly connected, edited and recorded. The writer believes that each of the twelve questions is possible of such demonstration as to be satisfactory for practical farm application in controlling rust activity, if not allowing of direct prevention.

It will not be profitable to discuss each of these questions in detail at this time but some of the better known features now stand out quite clearly and are quite illuminating. These will appear in the separate discussions in so far as it may appear necessary to clearness of expression.

Host Plants for the Uredo and Teletutospore forms of *Puccinia graminis*:. It is of immense practical interest to notice the various cereals and grass hosts for the "Black or Stem-rust of wheat for it is from these that the general distribution occurs. The following list includes those hosts which bear a rust of the essential structural features characteristic of *Puccinia graminis*:

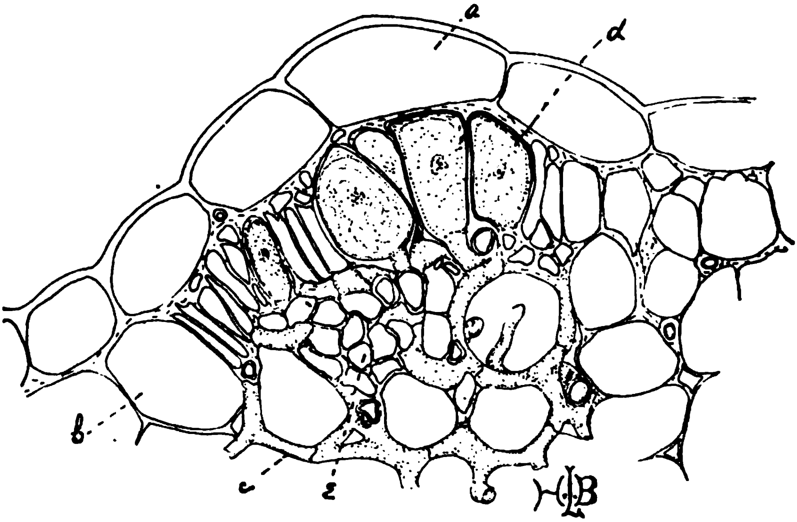


Cut 8. A drawing of a portion of a cross section of a leaf of wheat showing the arrangement of the "red" or summer spores, Uredospores of *Puccinia rubigo-vera* in theh spot or pustule. Notice how the skin on the epidermal layer of cells of the wheat leaf is ruptured and pushed upward, how the spores arise from the dense mass of filaments and how they are cut loose into the air. *a.* Cell of the epidermis or skin of the wheat leaf. *b.* Breathing pore. c. Part of the woody fibre of the leaf. d, A cell of the leaf containing leaf green bodies. *e.* Hyphal filaments of the rust plant. *f.* Matured summer spores. Magnification, approximately 400 diameters.

Agropyron caninum;. awned wheat-grass; *Agropyron occidentale*, western wheat-grass; *Agropyron repens*, quack grass; *Agropyron Richardsoni*, Richardson's wheat grass; *Agropyron tenerum*, slender wheat grass; *Agropyron violaceum*, purplish wheat grass; *Agrostis alba*, red-top; *Agrostis canina*, brown-bent grass; *Agrostis hyemalis*, fool-grass; *Agrostis stolonifera*, creeping brown-bent grass; *Alopecurus geniculatus*, marsh foxtail; *Alopecurus pratensis*, meadow foxtail; *Anthoxanthum odoratum*, sweet vernal grass; *Apera Spica Venti*, silky agrostis; *Arrhenatherum elatius*, tall oat grass; *Avena fatua*, wild oats;*Avena sativa*, cultivated oats; *Bouteloua oligostachya*, blue grama; *Brisa media*, medium quaking grass; *Bromus asper*, hairy brome-grass; *Bromus secalinus*, chess; *Bromus tectorum*, downy brome-grass; *Calamagrostis Canadensis*, blue joint; *Calamovilfa longifolia*, sand-grass; *Catabrosa aquatica*, water-whorl grass; *Chrysopogon avenaceus*, Indian grass; *Cynodon dactylon*, Bermuda grass; *Dactylis glomerata*, orchard grass; *Deschampsia caespitosa*, tufted hair-grass; *Deschampsia flexuosa*, wavy hair-grass *Distichlis spicata*, alkali grass; *Elymus arenarius*, downy lyme-grass; *Elymus Virginicus*, Terrell-grass; *Elymus Canadensis*, nodding wild rye; *Festuca gigantea*, great fescue grass; *Hordeum distichon*, two-rowed barley; *Hordeum jubatum*, wild barley; *Hordeum murinum*, wall barley; *Hordeum nodosum*, meadow barley; *Hordeum sativum*, barley; *Koeleria cristata*, prairie June grass; *Lamarckia aurea*, *Lolium perenne*, ray-grass; *Muhlenbergia racemosa*, marsh Muhlenbergia;*Muhlenbergia Mexicanna*, meadowMuhlenbergia; *Millium effusum*, tall millet-grass; *Phleum pratense*, timothy; *Phragmites Phragmites*, reed; *Poa Alpina*, alpine spear-grass; *Poa annua*, annual meadow grass; *Poa cassia*, *Poa compressa*, wire-grass; *Poa nemoralis*, wood meadow-grass; *Poa pratensis*, blue grass; *Poa trivialis*, roughish meadow grass; *Poa serotina*, false red-top; fowl meadow grass; *Sporobolus asper*, rough rush-grass; *Secale cereale*, rye; *Triticum monococcum*, einkorn; *Triticum Vulgare*, wheat; *Weingaertneria canescens*.

This list does not mean that the rust on each of these hosts is certainly one and the same species, but only that the usual characters used in classification indicate the probability. Only complete inoculation tests extending through all of the stages from aecidium to the teleuto form spores for each grass or cereal host can insure an exact grouping of these hosts. Even then the question as to whether the Uredospores ("red spores") of these grass and cereal hosts are able to infect any one or all of these, or whether each type is confined to a single host or to a comparatively limited line of nearly related hosts remains unsettled. The specialism which seems always characteristic of evolutionary development in living things would indicate that this last is the natural thing to be expected. Usually it is found that a parasite has learned after countless ages of attack upon and development with its hosts to meet the conditions of life afforded by the narrowed life features of that particular host and cannot meet those conditions afforded by host plants of a widely divergent character from these along which it has developed.

Various experimentors have completed tests which indicate that Uredospores of *Puccinia graminis* type which grow upon many of the grasses of the foregoing list may attack the wheat plant. The lack of a proper glass house at this station has prevented us from making the extended series of culture demanded by this work to definitely settle such points as are here involved; but I can affirm that



Cut 9. Drawing from a section cut through an oat leaf in such manner as to show the beginning of a young pustule of oat leaf-rust, *Puccinia coronata*. At *c.* and *e.* are shown the filaments of the rust fused together. The cell walls of the leaf have been eaten away at this point leaving only the rust filaments. *a.* represents the unbroken epidermis, skin, of the oat leaf showing the cells pushed upward by the young resting spores which are forming underneath The magnification represented is approximately 650 diameters.

the spores from a single barberry hedge located in Fargo have been used to infect the following plants individually and in crop form: wheat, oats, barley, wild barley, (*Hordeum jubatum*) wild wheat grass, (*Agropyrum tenerum*), quack grass, (*Agropyrum repens*) and *Avena fatua* successfully. The loop hole in this work is the fact that it is not known what host or hosts produce the winter spores, (teleutospores) which infected the barberry bushes, though the circumstances of immediate surroundings indicate the wild barley. However, wind borne dust may have transported such spores from any or all of the possible hosts within many miles.* We are also able to report the following successful infections with uredospores ("red" or summer spores) both on individual plants and upon a crop basis.**

The experiments of others and those we have conducted for a number of years indicate that the infecting powers of these two sorts of spores vary greatly when attempts are made to transfer hosts. Thus during the season of 1905, our inoculation tests showed that the aecidia spores from a certain barberry hedge would infect wild barley (*Hordeum jubatum*) with ease, also tame barley while the infection of wheat was less certain or easy of accomplishment; and attempts to infect oats were seldom successful. It was also often observed that the uredospores often assume a different color and apparent strength of growth when transplanted to different types of hosts. It is possible that carefully conducted infection experiments dealing only with the spores from the individual pustules may yet prove a greater form specialization than is now anticipated. However, present information seems quite enough to condemn the cultivation of the various species of the barberry shrubs in this country where the cereal crops are of so much importance.

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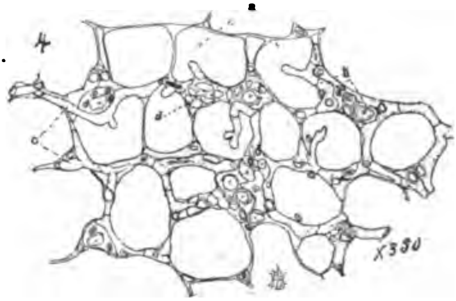
*It is evident that Uredinologists to settle these questions of host lines and the features regarding "bridging" hosts will have to confine their infection experiments to the use of pedireed spores and spore stages, using only spores from a single pustule for a single line of infection work. Our new culture house for this department is now being finished and it is hoped that we may be able to profit by this same advice.

**The infections in the latter case were made in the open so that the natural development and spread could be timed and noted.

What Shall Be Done With the Barberry Shrubbery? As indicated in previous pararaphs upon life histories, it is possible that the barberry shrubs may act as bridging hosts for all of the different forms of the stem-rust. If this is true, an aecidium pustule from the barberry might produce rust on wheat, oats, barley, or rye or other of the *Puccinia graminis* grass hosts that it happened to fall upon, no matter from which of these hosts the teleutospores came that produced the particular aecidium. It either does this in this manner or supports the aecidia pustules of each rust separately. Erickson, the noted Swedish authority, believes that the forms are closely specialized as is shown by the following quotation: "An aecidium arising from black rust on oats is able to infect, among the cereals, only oats, while an aecidium arising from black rust on rye or barley can produce rust (uredospores) only on rye or barley, and so on." "The different forms of black rust are thus entirely separate from one another in all of their stages, as uredo and puccinia on



Cut 10. A drawing of a portion of a section cut horizontally through the tissues of an oat leaf just beneath the spots where spores of the rust are beginning to form. The drawing shows the interesting manner in which the numerous rust filaments branch and fuse together. It also shows how intimately the filaments fuse with the cell walls, filling all inter-cellular air spaces, and dissolving the walls of the cells quite completely, at places. *a*. Cell cavity of the oat leaf. *b*. and *c*. Fused rust filaments. *d* Masses of filaments fusing to form a spore bed. Magnification 350 diameters.

the grasses and as aecidium on barberry.''[*] Unfortunately, the writer's experiments do not allow him to ascribe to these statements for we have often made transfers of urdospores from barley to wheat, wild barley to wheat and the reverse and also have on record some transfers from Avena fatua to young wheat under conditions which hardly admit of belief that there were admixtures of uredospores. Carleton[**] has also on record some tests which run counter to the Erickson statements. This work all needs to be carefully redone.

In any case, all experts agree that the stem-rust of each of our cereal grains and of many of the native grasses can infect the barberry bushes and that aecidium spores from shrubs formed in early spring do infect different members bers of the cereal crops, causing more intense rust destruction in the immediate vicinity of the shrubs. That these red spores developed from these barberry infections are of greater vitality than ordinary and that any uredospores may resist drying in the open air for a number of days and may be blown about by the wind for many days, thus being able to reach distant fields, the writer has many times been able to demonstrate. The aecidium spores themselves are also found to be able to resist drying for a number of days and then produce infection.[***] It would thus not seem necessary to assume that the influence of barberry rust upon wheat fields should of necessity be looked upon as only local. Kentucky and Illinois grown barberry rust spores may readily have a secondary affect upon the wheat fields of Minnesota and North Dakota, by infecting local grasses and grain fields from which a more virile set of red spores arise to be blown northward by general winds.

While at the Indiana Experiment station in 1888-9, I had the opportunity to observe the locally increased virulence of stem-rust upon different plots of wheat near rusted barberry bushes. I have had many opportunities to make similar observations since and think I am safe in the assertion that the effect of a few clumps of rusted barberry bushes may be easily noted for many rods in the direction in which the winds prevail during the time at which the aecidium is maturing spores. The shrubs are not native to the northwest, but all centers for the barberry bush which I have observed have proved to be marked rust centers in rust years. The city of Fargo has several hedges and each rust season the wild barley and the wheat grasses of the immedinate vicinity of these hedges are rusted almost to extermination, furnishing clouds of red spores ready to be wafted to the farm crops by the time that barley and wheat are ordinarily in blossom. Each year, the farm crops, directly northwest and south eastward from Fargo suffer more intensely from stem-rust than any

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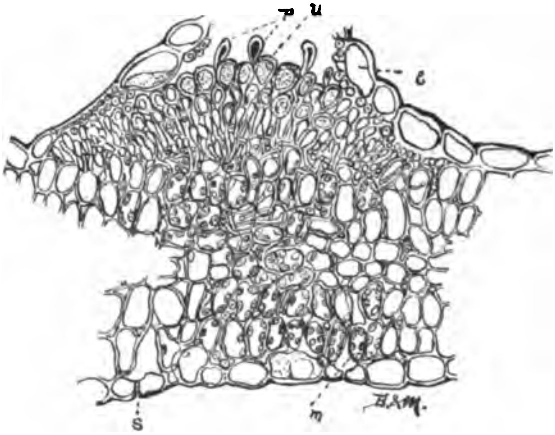
[*] A general Review of the Principal Results of Swedish Research Into Grain Rust. See Translation in Botanical Gazette, Vol. 25, No. 1—p 30—1898.

[**] See U. S. Bureau of Plant Industry—Bulletin No, 63—p—15

[***] The first note upon this feature of the rust question, see ''Wheat Rust: Is the Infection Local or General in Origin?'' in Agricultural Science, Vol. 5, Nos. 11 and 12—1891.



Cut 11. Drawing of a portion of a section cut through a flax leaf showing pustules of flax rust, *Melampsori lini.* Notice the numerous filaments of the rust which penetrate between the cells of the flax leaf and the fact that the most mature rust spores are pushing up or breaking through the skin layer of the leaf. The drawing illustrates the point that several generations of spores follow each other in the same pustule of summer spores.

other area of the Red River region, the disease gradually diminishing in general destructive powers as distance intervenes. During the season of 1904 and 1905 I feel sure that the influence of the Fargo hedges contributed extensively toward crop destruction for many miles extending over a fan shaped area north and westward, and south and eastward to the heavy wood lands in the direction of the prevailing winds. I cannot say whether if all barberry hedges were destroyed that there would be no wheat or barley or oat rust, but I am sure that these hedges contribute largely to increasing the amount and vigor of rust in their immediate vicinity. I have the past season traced the increased intensity occasioned by a single hedge for many rods upon wild barley (*Hordeum jubatum*) of the prairie and onward rods into a large wheat field before stem-rust was seen elsewhere in quantity. I believe its direct influence extended for many miles and its secondary influence through the first uredospores for many miles more.

The barberry shrubs are ornamental thorny affairs used for hedges and clumps upon lawns. There are many shrubs which are good substitutes for these purposes; and if there were national or state laws which might result in the destruction of these rust breeders, much might be learned, regarding rust. At least one set of often proven rust criminals would be disposed of. The shrubs are not widely used and but a small amount of actual digging would be necessary to uproot them in any state of the union.* It must, however,

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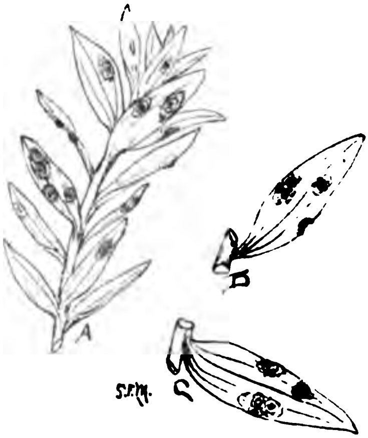
*In short the argument for uprooting the barberries is that stem-rust of wheat, oats and barley, *Puccinia graminis*, produces its aecidium or spring stage of spores upon the different species of the barberry (Berberis) While it is now known that the rust may live over winter in the uredo-stage, (see page 641), many rusts seem unable to persist in the absence of their aecidial hosts. It is believed by many botanists that this is the sex stage or its equivalent and it is reasoned that if *Puccinia graminis* were deprived of this aecidial stage because of the disappearance of its natural hosts, the barberries, this rust might gradually lose its vitality and pass away. This is good sanitary doctrine and follows known experience in the case of many infectious diseases of man and animals. For example, Trichinosis in man hogs and rats; tape worm; plague; etc.

The following species of the barberry bear the aecidium (See *Saccardo*).

be remembered that the action of a single state or a few good intentioned individuals can have but slight general influence; as spores may be carried in air currents for unlimited distances falling here and there according as storms or rebounding air currents may strike the earth.



Cut 12. This figure shows the spotting effect which the earlier growths of flax rust produces upon the leaf. The color of these pustules are usually quite yellow. This rust was so intense in some crops during the season of 1905 that the leaves fell away before the plants were fully in blossom.

The Wintering of Rusts: In the winter of 1888, the writ-

Species name	Native range
Berberis aristate	Himalayas.
Berberis emarginata	S. Europe to Himalayas.
Berberis canadensis	Alleghanies.
Berberis vulgaris	Europe to East Asia, Naturalized in America.
Berberis aquifolia	British Columbia to Oregon.
Berberis repens	Western N. America.
Berberis neubertii	Garden origin.

Of course there may be other hosts for the aecidium of this rust but no botanist has been able to discover such, and all natural argument is against the probability of its existence. At most, the world would only lose a thorny shrub of some beauty and investigators would have a chance to see what would happen. The wheat crop of the United States is worth many such experiments.

er conducted a series of observations* which established the fact that the lesser rust, leaf rust of wheat, *Puccinia rubigo-vera,* can pass the winter upon and within living leaves of winter cereals in the latitude of Layfayette, Indiana. Carleton** and other investigators have since made similar observation for different points: It is now generally conceded that that species of wheat rust readily survives the winter in the red spore stage producing new pustules every month of the year, in some localities. During the winter of 1904 and 1905, the writer made collections of these spores in fresh viable form, in December and January in Kansas, Oklahoma, Missouri, Mississippi, Illinois, Wisconsin, Minnesota and North Dakota. In the latter state viable spores were procured from under the snow throughout the winter months, and it was observed to begin early spring developments of new red pustules upon the green base of leaves of winter wheat the dead tips of which bore pustules at the beginning of winter.

Duing the winter of 1888-9, I also found uredospores of *Puccinia graminis* which were viable but was unable to convince myself that either these red spores or the mycelium could carry this rust over the winter. Observations made during the winter of 1904-5 now allow one to affirm that there can be no doubt that the stem-rust, *Puccinia graminis,* is also able to pass the winter in the uredospore form. Viable spores were collected late in October at St. Louis; Dec. 25th at Dallas, Texas, and in January quantities of them were being procured upon winter wheat at Riverside, Illinois. Later some were procured on quack grass at Lake City, Minnesota, and a quantity of viable spores were taken from the leaves of quack grass and wild barley frozen in ice at Fargo in March of 1905. By numerous experiments I have often found that the resistance of the summer spores to drying and exposure to air is much greater than has usually been supposed.*** There can be no question that such spores

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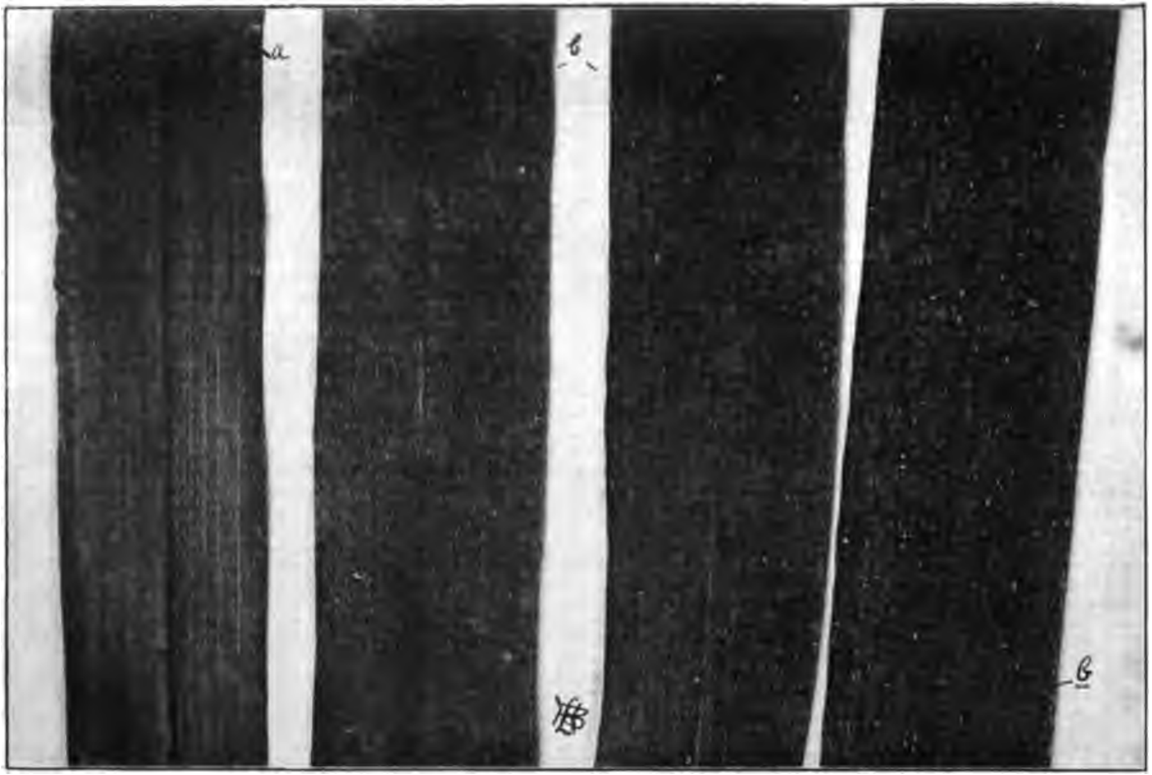
*See Bulletin No. 26 of the Indiana Experiment Station page 13. page 13.

**Bulletin 16, Div. Veg. Path, U, S, Department of Agriculture,

***See Bolley, in Agricultural Science, Vol. V Nos. 11 and 12—p 263 —Dec. 1891.



Cut 13. This photograph shows the characteristic spotting occasioned by leaf-rust, *Puccinia rubigo-vera*. The leaf a, grew inside of a glass cage from the same seed that produced leaf, *b*, on the outside of the cage. Compare with Cut 14. Magnification 2 diameters. See page 644,

could be blown about by the spring and summer winds for days without loss of vitality, thus being carried to distant fields. I have kept such spores exposed to sunlight and air during the entire month of August, and yet found a viability exceeding five per cent.

The fact that spores frozen in snow and ice retain their germinating powers through the winter makes it probable that the uredospores survive the winter in northern states even more surely than in the more southern regions. Here in Dakota and northward snow often falls upon rust infected green foliage and thus protect it until late spring, freeing the spores to be blown to the young foliage to the southward, even though the spores may not generally survive the spring months at the points where they may have wintered. The drying autumn months southward tends to check the formation of new pustules of red rust, uredospores, during the autumn and winter months.

There are other features regarding the first outbreak of rust in the great wheat fields of the northwest, however, which do not appear to be fully solved by these observations or wintering of the uredospores. It takes, for example, eight to thirteen days for a uredospore infection to develop sufficiently to produce a pustule of new spores. It would thus be practically a month after the wheat is up before one could naturally expect any general infection; yet during the seasons of 1904 and 1905 miles and miles of Dakota wheat in the second blade showed even outbreaks of pustules of *Puccinia rubigo-vera* on all plants with a regularity so great that one must assume that the air had borne countless numbers of these spores from a distance thus early in the spring or that they were already upon the ground in immense numbers; or that there is yet another mode of general infection not yet understood. The outbreak of *Puccinia graminis* in the uredo form, though coming always later, comes likewise in an even general manner over great areas, missing no plants. Various natural questions arise:

Can these first general infections come from uredospores evenly distributed over the soil from the last season or from the early southern crop, being splattered over the young wheat plants by contact, splattering of rain drops, etc.?

Our observations upon the wintering of these spores would point this as possible. To test this idea, an area of soil 16 in. deep and 16 ft. square was thoroughly sterilized by steaming during the spring of 1905. The rust came just as on the unsterilized plots. Thus the disease must have come via. the seed or air to this particular bed.* In the summer of 1898, the writer planted wheat and oats, and then set over certain areas of the ground thus planted three small glass houses or cages properly ventilated but so arranged that no spores could gain admission. The grain grew to maturity of straw. No rust formed inside the cages but all plants outside were being badly attacked. This experiment was repeated in 1905 with wheat with like reseults. See cuts No. 13 and No. 20. This would seem to point to the conclusion that rusts spread from plant to plant only by way of the air. It is yet possible that if rust attack may come by way of the seed, these cages may not give a proper or sufficiently normal growth of the wheat plant to support the internal growth of the rust parasite. This seems hardly probable for when the cages were removed on July 23, 1898, so that the plants were exposed to the air, in ten days time all plants become thoroughly broken out with rust. The cage containing oats in 1898 also produced much oat smut a fungus which comes by way of the seed; and again in the test of 1905 pigeon grass, which came up as a weed in one of these cages, fruited freely and matured smut in some of the heads, showing that the crop at least furnished normal conditions for that type of fungus.

The Mycelium as a Possible Source of Spring Infection: Associated with the wintering of the uredospores goes also the possible passage of the winter through the means of the living rust filaments which persist in green leaves and other green parts of wheat and other grass host plants which may

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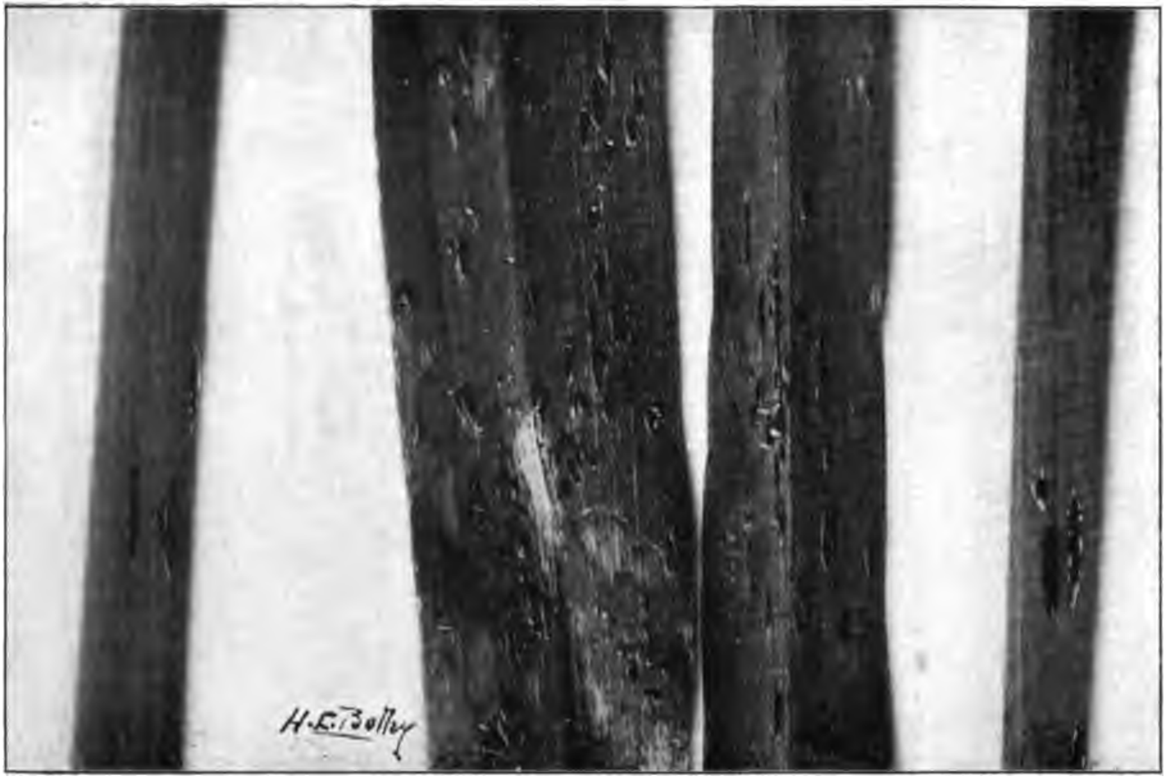
*This extensive soil sterilization experiment was conducted by removing the soil layer by layer in layers of 4 inches depth; placing it in gunny sacks and sterilizing the same by discontinuous steaming, after which the soil was replaced layer by layer in the proper order.



Cut 14. Photograph of typical leaves and stems of oats attacked by *Puccinia graminis*, stem-rust. Magnification 2 diameters. Compare with Cut 18.

chance to live through the winter. This feature I consider to be thoroughly proved for *Puccinia rubigo-vera* and quite possible for *Puccinia coronata* leaf rust of oats; and *Puccinia graminis.*

There is yet the further possibility that broken particles of mycelium from the previous years crop may act as agents of infection. It is a well known fact that there are few of the imperfect fungi which cannot be propagated from broken bits of old mycelial threads If the viability of such rust materials could be shown the speed and excess with which general outbreaks occur would be easy of explanation. While such filaments have at times every appearance of life and viability, I have been unable to cause infection with any such material.

The Internal Infection of the Wheat Grain by Rust: A New Observation: During the season of 1898, Dr. Jakob Erickson, the noted Swedish Uredinologist, proposed his noted theory that rusts of cereals may be inherited from crop to crop by way of seed as a modification of the protoplasm of the host and that outbreaks of the rust then occur with greater or less severity according to the food and weather conditions which affect the diseased wheat plant.* It was to test the efficiency of Erickson's arguments that the cage experiments just cited were first planned.** All features seemed to disprove his conclusions. However, the great rust invasions of Dak. during 1904 and 1905 have furnished many features which cause me to doubt whether, after all, rust does not have a mode of crop infection by way of the seed. Many farmers believe this firmly. We have been unable in any certain way to substantiate the belief. As yet all proof seems only circumstantial. We have, however, made some very startling observations and, if wheat rust ever is really transmitted from crop to crop via. the seed grain, we are now able to point out a much more rational possible explanation than that proposed by Prof. Erickson. It is a well known occurrence in the spring wheat belt that the chaff scales and rachis of the wheat heads may be thoroughly attacked by *Puccinia graminis.* When this occurs the grains are sure to be shriveled and often bear black points, blackened or browned germ ends. These black points led the writer and Mr. F. W. Pritchard to investigate such grains to ascertain whether the mycelium (the filaments) of the rust ever enters the grain so as to perhaps cut off the food supply, causing the grains to shrivel. The results of these studies now allow us to make the definite statement that wheat grains from badly rusted mother plants quite often, indeed, in some strains are quite uniformly internally infected by wheat rust filaments to such extent that the spore beds are formed bearing both uredospores and teleutospores (summer spores and winter spores) beneath the bran layer. In some samples of the rust infected crop of 1904, as high as thirty per cent. of all grains harvested were so infected with the stem-rust (*Puccinia graminis*) and spore beds bearing both types of spores were found variously located beneath the bran layer of the grains and about the embryo wheat plants. The spots or spore beds are most commonly located immediately at the germ end, causing a black or blighted appearance, but are often found on other portions of the berry, especially along margins of the grooves. It is also found that these grains, thus affected, germinate as freely as any other wheat grains. It must not be assumed from this that all black pointed wheat grains are due to rust. Alternaria and other types of fungi take an active part in this discoloration.

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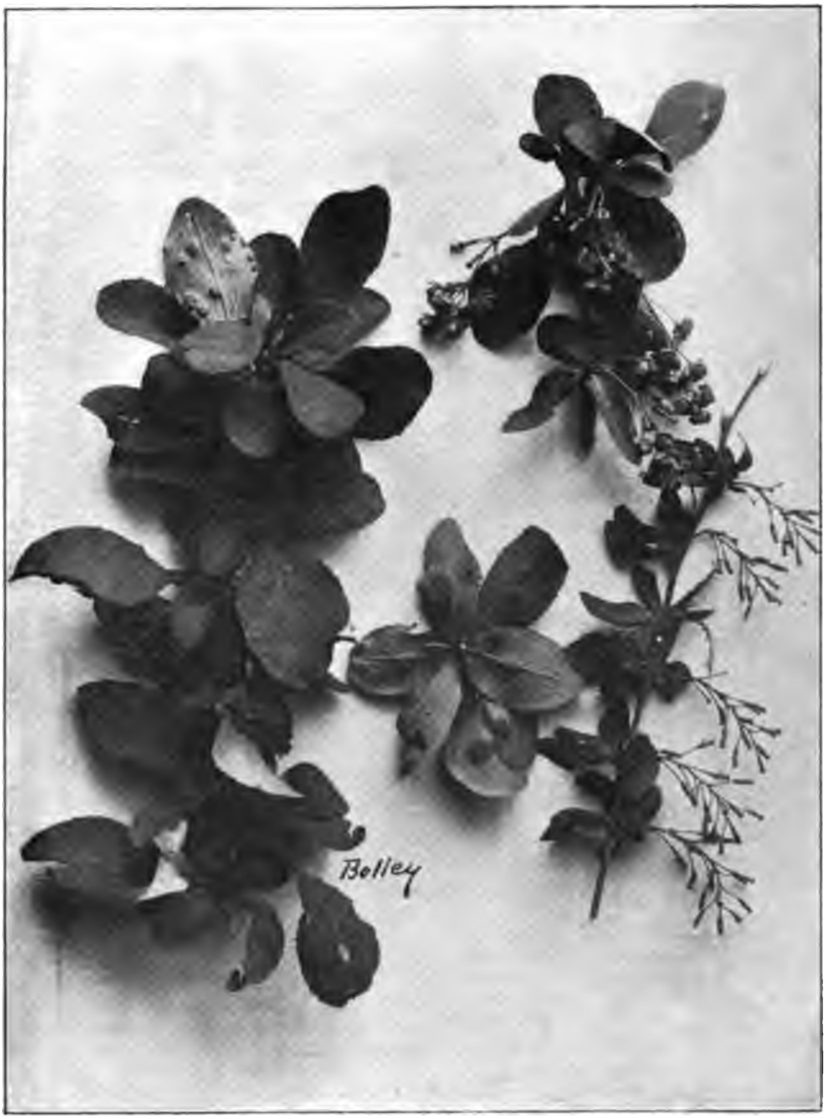
*See Eriksson in Bot. Gazette, Vol. 25, No, 1—1898,

**For full report on this work see Centralblatte f. Bakteriologie, Parasitenkunde u. Infectionsskrankheiten, 2 Abt. 4 Band—1898—Nos. 23, 24 and 25.

These new observations have opened up a new line of investigation, but it is too early to affirm that wheat rust attacks may come in this direct manner from the seed. We have been able to get growths from these internally located rust bodies; but as yet have been unable to get any proof that they can cause rust to develop in the plants which grow from such attacked grains. Such black-pointed grains were planted in the glass cages during the season of 1905, but no rusted plants occured in the cages; while the same type of wheat planted outside of the cages became thoroughly at-



Cut 15. Photograph of leaves, flowers and young fruit of the common barberry showing pustules of the stem-rust of wheat growing upon the underside of the leaves, *Aecidium*, or spring stage of *Puccinia graminis* See page 637.

tacked at once by *Puccinia rubigo-vera* and later by *Puccinia graminis.*

If later experiments should confirm this possible mode of rust propagation, these observations must undoubtedly throw a new light upon the entire rust problem and place another strong emphasis on the importance of proper seed selection and grading of grain in farm practice. The fact that rust thus attacks the wheat grain by way of its attachment is also an apparent explanation of why rusted wheat often fails to properly mature the seed even though there is yet plenty of nourishment left in the mother plants.*

Winter Wheat and Rust in the Spring Wheat Belt: It is a peculiarity of nature that certain forms of life by their existence favor the development of certain other species. It is also a fact that the appearance of some living form is sure to be followed by the extinction of other species and the nearly related species are surest to suffer. Spring wheat has always been at a disadvantage when winter varieties have been introduced. It is true the grain from the spring crop has always commanded the best rating for milling value, and that it always takes less labor and time to produce the crop; but it is equally true that very soon after winter wheat has been introduced farmers have had to give up the culture of the spring crop. One does not have to go far to cite examples. Northern New York State, Eastern Ontario, Mich., and Iowa, all were once noted for their fine crops of spring wheat. The crop ceased to yield soon after the gradual introduction of the winter crop. No one has ever vouchsafed a reason why spring wheat can no longer be produced in the winter wheat

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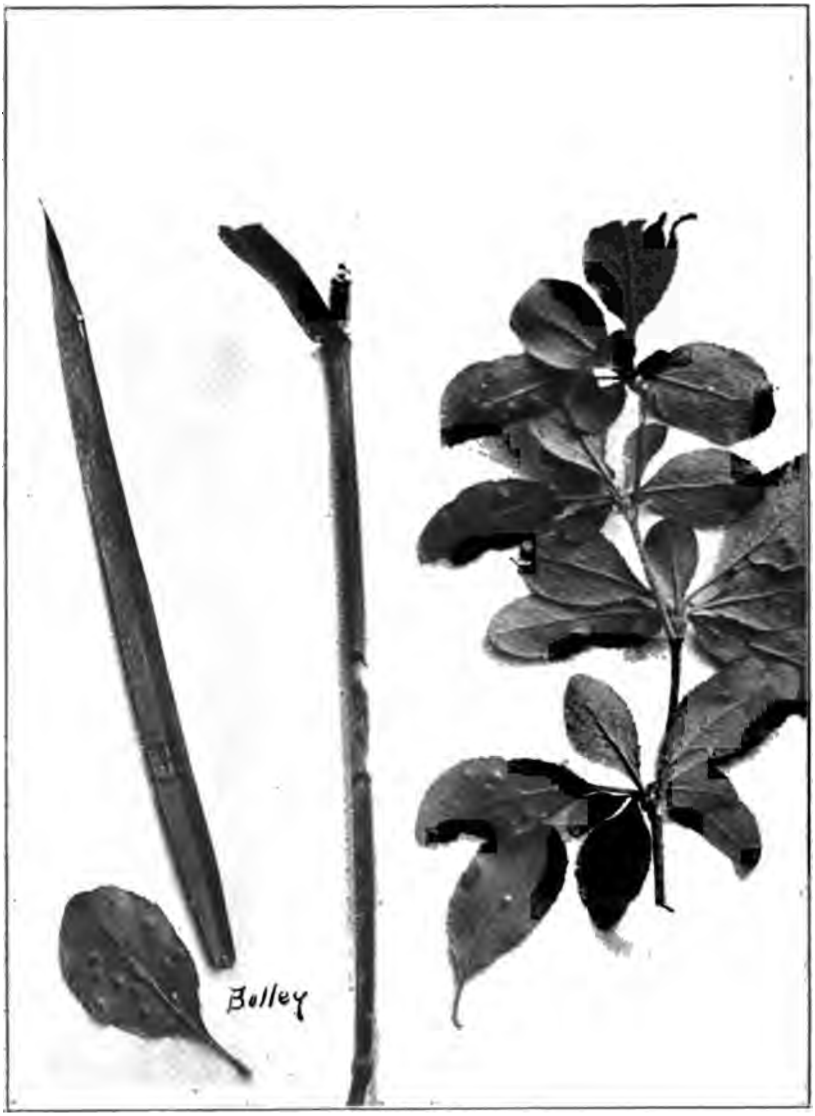
*Late communications from Prof. D. McAlpine of Australia, a mycologist of note, indicate that he is convinced that certain grass seeds received by him from the U. S. Department of Agriculture have introduced into Australia certain species of rust. He notes the occurence of *P. coronata* on*Beekmannia erusaeformis*, barnyard grass, and of *P. montanensis* on *Elymus condensatus*, wild rye grass. If it is true that these rusts were not already in Australia, this would seem to prove rust infection via. the seed. This might come about through internal infection or through introduction of spores, and, of these, suspicion would point strongly to the uredospores. But no one has ever proved that these may work from below ground—even if proved to be so retentive of vitality.

belt. All will agree with me that it starts out well but soon rusts and "never fills."

It is possible that the fact that where winter wheat can uniformly winter its increased yield over the spring varieties would be sufficient to account for the fact that farmers almost at once abandon the spring crop; but this cannot account for the loss of the spring crop in those regions where the winter crop never does obtain to the yield which was once characteristic of the spring crop. Our observations prove that winter wheat varieties harbor the rusts throughout the winter months and develop the spores early the next spring and summer, at least one month earlier than the spring crop of the same region could do, placing the spring varieties at once in jeopardy. If a heavy infection of the spring crop can be started at any date before the blossom stage, that alone is sufficient to cause the crop to fail to fill. For several years my observations show that the small strips of winter wheat being experimented with throughout the three northwestern states of Dakota and Minnesota are first severally attacked by stem-rust approximately one month before the general attack comes upon the surrounding spring crop. I need cite but a few observations in this line. July 18th the Manager of Dakota Farmer of Aberdeen wrote: "It has just been discovered that fifteen acres of winter wheat near Aberdeen is badly affected with black rust. Adjacent fields of spring wheat show no signs of it. We would like to have your opinion in regard to the probability of the rust spreading from this piece of grain to the surrounding fields of spring wheat. In your judgment is it advisable to destroy this grain in order to prevent spreading? Kindly wire at once."

Our answer had, of course, to be: "It is now too late; the red spores have already been scattered by the wind for some days. That crop has already done its work of distributing rust spores to the surrounding spring fields." They were then already breaking out with the first general infection. The fact that the people in this vicinity noted the severe attack upon the winter wheat plot and became alarmed indicated to me that my own observations and thoughts were not mere mental fancies.



Cut 16. Photograph of leaves of barberry showing spring stage of *Puccinia graminis*, and a stem and leaf of wheat upon which artificial infections of the rust were produced. The ink lines show where spores were placed. The spots between are pustules of summer spores which arose. No rust broke out on any other part of this wheat plant. See page 636.

The Agricultural Experiment Station plots at Fargo have always borne some plots of winter wheat. During the season of 1905 I made the following rust observations:

February 17th found the red spores of *Puccinia graminis* on green leaves of *Agropyron repens* (quack grass) frozen in solid ice. 85-90 per cent. of these germinated on first trial.

February 22d, found uredospores of Puccinia rubigo-vera on green leaves of *Agropyron repens* (quack grass) frozen in snow and frozen in ice. These spores gave a high percentage of germination.

April 9th found pustules of red spores of Puccinia rubigo vera on green leaves on the plots of winter wheat at the Experiment Station at St. Anthony Park, Minn., and an abundance of such spores upon stools of volunteer winter rye. 90-100 per cent. of these spores germinated when given trial.

April 13th, duplicated this test by like findings at Fargo. Found that these spores even on the dead leaves would germinate if found frozen in ice.

May 13 to 23, received red spores (uredospores) by mail from Huntsville, Ala., Honey Grove, Texas, Fullerton, Kentucky and Conway, Arkansas. All retained viability and germinated freely when given opportunity.

June 1st, winter wheat generally attacked by *Puccinia rubigo-vera.*

June 11th, barberry bushes showing many spores of *Puccinia graminis.*

June 27th, examined many fields of spring wheat and oats. Found only one pustule of *Puccinia graminis,* that on oats: but found that Russian varieties of winter wheat are becoming thoroughly infected and some pustules are breaking out.

Trials of infection experiments using Fargo grown barberry spores effective on wild barley (*Hordeum jubatum*), field barley, wild wheat grasses (*Agropyrum tenerum A. Spicatum* and *A. repens*) also on wheat.

June 27th, all winter wheat samples have about lost their leaves by the attack of Puccinia rubigo-vera (leaf rust). The black stage of this rust is now well formed on this wheat while the general infection is only beginning on the spring wheats. Puccinia rubigo-vera is at least three weeks more advanced on the winter wheats than upon the earliest spring fields.

July 8th, stem-rust, Puccinia graminis, now thoroughly general on the winter wheat plots. It seems hardly probable that this general growth came from the few pustules which were first observed.

These general infections must have come from the air or have already existed internally. As on June 17th there were an abundance of aecidia on the Fargo barberry bushes; it is possible that the supply of first infecting spores came from these, but more probable, that the infection, if from air, came as clouds of red spores from distant fields, farther southward.

No Puccinia graminis (stem-rust) yet appearing on the spring wheat fields.

July 20th, *Puccinia graminis* just becoming easy to find in the red stage on the fields of spring wheat.

These observations need no comment other than to say that, it is evident that both species of rust appeared upon the winter cereals at Fargo in strong form and distributed to the winds great quantities of red spores at least two weeks earlier than on spring cereals. While sufficient spores blow great distances to start small separate infections, it is probable that only the large general infections which get started early and sweep over local regions from field to field result in such devastating crop destruction as occurred in the Dakotas and Minnesota in 1904 and 1905.

It may be of importance to have the winter wheat belt pushed further and further northward as many persons advocate, but until some rust resistant varieties have been found or bred, I believe it wise to do everything possible to keep the line of demarkation between the winter wheat and the spring wheat belts sharply drawn. I believe that farmers of the main spring wheat belt should in every way possible discountenance the growth of small strips of the winter varieties. Let those who are on the southern border of the great spring

Cut 17. Photograph showing alley way between beds of experimental wheat and barley. These beds were attacked by rust before any neighboring wheat beds and were more severely injured than any wheat in the vicinity. The rust was heavy on the barberry, and the intensity of rust in the wheat could be distinctly noticed for many feet about. See page 637.

wheat belt do the experimental work of widening the range of the winter cereals.

It is often said that winter varieties resist rust more than do the spring kinds, but this is not quite true. Indeed, they are quite as commonly destroyed as any. With them as with the spring sorts all the common varieties yet known rust quite completely if they chance to be late in maturing on a rust year. The winter sorts tried at Fargo during 1905, including several promising Russian sorts, were almost destroyed by the stem-rust.

What Rust Does the Damage: It is a common belief that "red" rust does but slight harm. Many will even argue that it "removes the leaves and causes the grain to ripen," a very foolish thought. From association with many persons in the fields during the last two epidemics, I am convinced that by "red" rust is meant, usually, the red stage of the orange leaf-rust, *Puccinia rubigo-vera.* Even Mr. M. A. Carleton* (*b) falls into the error or assuming that if it had not been for the stem-rust no particular damage would have been done. He says: "In the season of 1904, as well as in all other seasons when rust has done a great amount of damage, it was this black stem-rust that caused the damage."

So far as North Dakota is concerned this statement is far from fact. In 1888 the leaf rust was so intense that the ripening period was delayed and nearly entire crop ruined by frost. Very few farmers claim that the black stem-rust had much to do with the troubles that year. In the badly rusted districts of Minnesota, North Dakota and South Dakota in 1904, the wheat grains were wilted and began to shrivel before Puccinia graminis was even well developed on the straw; and this was even more true of the season of 1905. Both of these rusts are liable to be destructive to grain formation either when acting together or separately. It is wholly a matter of the amount and strength of infection, the date of infection, and the conditions under which the crop is growing. I have seen plump wheat on straw which was thoroughly covered with the spores of both species of rust and I have seen many sections of wheat practically destroyed by the orange leaf-rust, Puccinia rubigo-vera, fields in which one had difficulty to find straws bearing any pustules of the black stem-rust.

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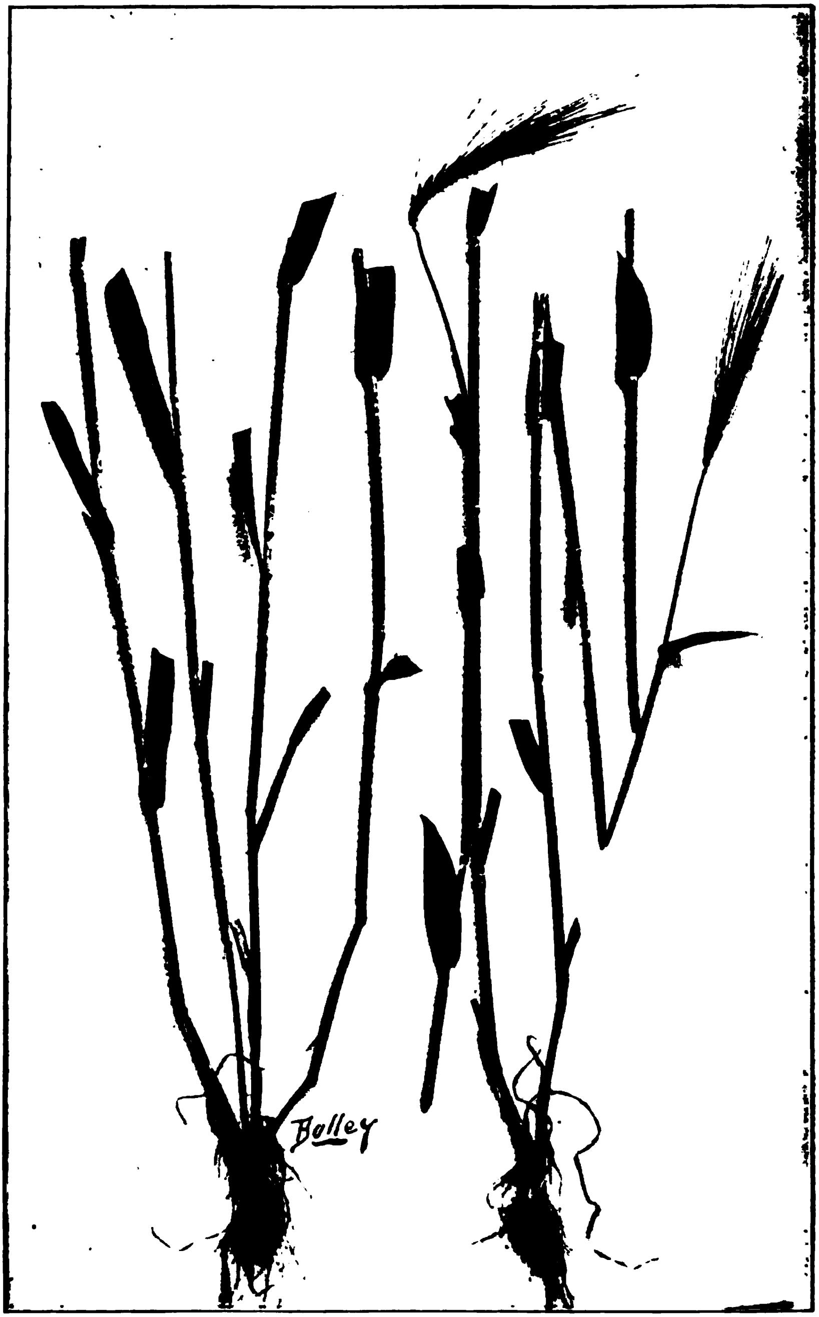
*See "Lessons from the Grain Rust Epidemic of 1904," Farmers' Bull. No. 219 page 6,

The characteristics of the attack in 1905 was that the final general infection of the red spore stage of the orange leaf-rust was so severe that the foliage of the wheat crop was practically blighted. The leaves and sheaths in many fields were so thoroughly killed that the stem-rust never had opportunity to make much of a showing though the first infection of that rust was early and quite general. The result was that many people were much surprised that the stem-rust seemed to fail to develop after the first start made. It could not do so as the leaf-rust had preceeded it so thoroughly that the second crop of red spores of the stem-rust did not generally have a chance to develop. Any rust which comes early enough and strong enough to kill the foliage before the wheat is in the dough will surely cause shriveled wheat under ordinary soil and weather conditions. See next paragraph.

How Rust Causes Damage: Rusts are not merely surface affairs as many seem to think. The rust filaments penetrate all of the tissues of the host plant in the immediate region of an infection spot or pustule. Indeed, in a wheat plant in which the grains fail to fill because of rust, there is hardly a single cell that is not many times perforated by the branching fungus threads. See cut 8.

One can tell where pustules of spores will break out several days before they mature by the appearance of lemon yellow translucent spots due to the death of the cells and the disorganization and disappearance of the green coloring matter (leaf-green or chlorophyll) of the wheat plant. The rusts are such perfect parasites that the filaments (hyphae) pass directly through the living cell walls of their host plants and make practically perfect fusions with the cell walls. They only seem to destroy the cellular structure at the points where the spore beds form, but at these points only the un-



Cut 18. Photograph of severely rusted barley due to the infection from the barberry bush shown in Cut 17. See pages 637, 640.

derlying woody cell and the skin layer of cells remain, and the latter is finally ruptured. See cut 9.

TABLE SHOWING THAT MOST TRANSLUCENT LEAF SPOTS BECOME RUST PUSTULES.

Test No.	July 28 '05 Number of Translucent Spots Present*	Number of Pustules Broken Out			
		July 31	Aug. 3	Aug. 7	Aug. 10
1	2	0	1	4	5
2	2	0	0	0	(Leaf dead)
3	3	0	1	1	(Leaf dead)
4	3	0	2	2	Leaf dead)
5	2	0	0	1	2
6	4	0	0	2	3
7	3	0	0	0	1
8	2	0	0	2	(Leaf dead)
9	3	0	2	5	5
10	3	0	0	1	1
11	1	0	1	1	(Leaf dead)
12	1	0	0	2	3
13	3	0	0	3	(Leaf dead)
14	2	0	0	1	2
15	3	0	0	1	(Leaf dead)
16	5	0	1	1	(Leaf dead)
17	1	1	1	3	3
18	3	0	0	2	2
19	3	0	1	2	2
20	3	1	1	4	4
21	3	3	4	4	4
22	2	0	0	0	0
23	3	0	0	2	(Leaf dead)
24	3	0	0	0	(Leaf dead)
25	2	2	4	4	(Leaf dead)

The rusts from the start begin to sap the plant's strength by absorbing the cell sap and disorganizing the protoplasm and chlorophyll. This work early prevents a sufficient flow of food matter to young wheat grains which are forming in the head, hence the maturing process is retarded. Indeed, the entire upper straw seems to be unable to mature. One can readily understand why, when he remembers that the food manufacturing areas of the wheat plant is represented by the green matter of foliage and the green portions of the upper stem. In 1905 leaf-rust completely blighted the leaves in about three days time while the grain was yet in the milk stage. There was thus left only the upper necks of the straw to do the work of starch and protein manufacturing. The ripening of the crop therefore went on very slowly. Besides in most cases the necks of the straws were also finally thoroughly infected by the stem-rust. If this rust chances to come early enough it is able to so thoroughly break open the stem that a few drying days completely evaporate the moisture from the straw, and the grain is sure to shrivel.

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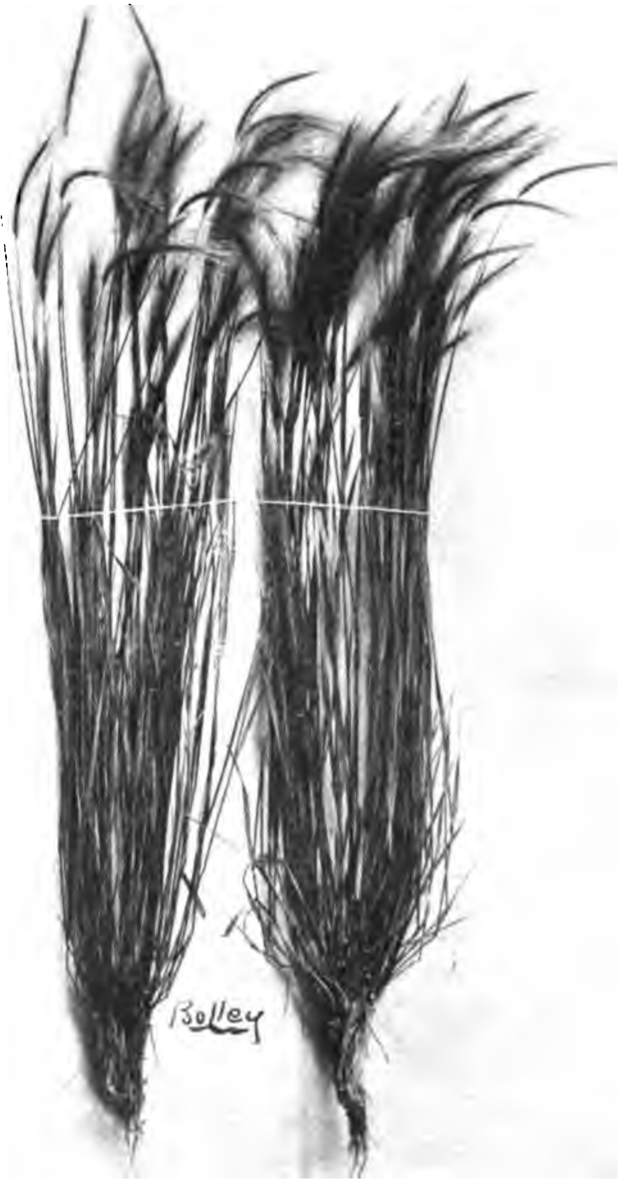
* July 28, 1905, we made India ink marks around the spots to mark off the areas which we wished to observe, and records were taken on the developments from the translucent spots. The results of these observations were that most such spots finally developed into uredo-pustules.

Our observations also show that in extreme cases the filaments of rust actually invade the attachment of the young grains with the straw of the head (rachis) at times completely cutting off all regular connection.

General Conditions Favorable to Rust Growth and Destruction of the Crop: As rust is due to the growth of a plant upon and within the tissues of the wheat straw, naturally it must have its own peculiar conditions of growth satisfied. There must be the spores, proper moisture, proper temperature for spore germination and the right sort of food matter, or there will be no outbreak of rust. These conditions may be called the primary conditions, necessary for the development of rust. There are many secondary and local ones which favor rust development. So many elments of soil, water and plant growth enter the question that it is confusing to attempt to explain all of the noticeable conditions which help to account for general rust destruction. One cannot make general assertions which are fully applicable to a great area such as North Dakota. We can, however, summarize a few of the most obvious conditions which influence rust development: (1) The straw of the crop must be susceptible to rust infection, that is to say, must be soft or succu-



Cut 19. Native wild barley, *Hordeum jubatum*, a weed pest and one which produces wheat rust spores in great abundance. See page 640.

lent at the time the rust spores alight upon it. To explain, some varieties of wheat straw are soft, more succulent, more open to attack than others; and all varieties are more or less susceptible at some particular stage of growth or maturity. Each variety is more open to attack by rust just at the period following heading time to the point of full blossom stage. If this period of growth is prolonged by soil or weather conditions there is liability of extensive rust infection. (2) The wind must be such as to bring to the heading crop a good supply of rust spores. (3) The elements of moisture and temperature are most confusing. These must be right during the blossom and milk stage or there seems to be no general rust infection or great destruction following. Each of these conditions may be quite variable during the season, indeed, usually do vary widely during the period of development mentioned. The most effective rust infection weather may be described as muggy, showery, sultry, rather still hot days, with foggy, cool, dewy nights, at about the blossom period. Just following the infection, cool, moist, slow growing, showery weather may result in the most general rust infection, and in the greatest breaking out or rupturing of the straw,

Wind: Although it is possible, as shown by our observations, that the three chief species of grain rust winter here, so far as North Dakota is concerned the chief source of rust —spores lies to the southward, for the reason that the cereal crops and native grasses mature there earlier allowing the rust spores to mature in time to blow to the later crop north and westward. Thus the southeast winds are chief carriers of rust spores, and these spores generally come from field to field, though there may be nothing regular about the order of infection. Great areas of wheat may miss destructive infection because of special conditions. The falling of spores and hence the local infection of a given area may depend largely upon the occurrence of local rains or showers or wind storms. As storms strike the earth, rebound and return to earth at other points, they pick up and irregularly distribute spores from which early outbreaks may occur in widely separate areas. Each new local infection serves as a center for the larger general infections.

That spores are daily carried in the air and at times deposited was easily proven by the following tests.* Ordinary soup dishes, seven inches across the top, were half-filled with distilled water and were exposed upon a post five feet above the ground for fixed periods of time. After sedimentation in a centrifuge observation upon the spore content were made. Some of the dates and observations are here given.

July 21st, plate exposed 45 minutes. Found 2 Puccinia rubigo-vera in six mounts of the sediment.

July 24th, plate exposed 30 minutes. Found in six mounts of the sediment six uredospores of Puccinia rubigo-vera, 4 uredospores of Puccinia graminis and one teleutospore.

July 26th, plate exposed 30 minutes. Found in six mounts from the sediment eight uredospores of Puccinia graminis and thirty-one uredospores of Puccinia rubigo-vera.

July 28th, plate exposed 30 minutes after a heavy rain of previous night. Found in six mounts from the sediment eight uredospores of Puccinia graminis and four of Puccinia rubigo-vera.

July 29th, exposed as above. Found fourteen of Puccinia graminis and six of Puccinia rubigo-vera.

July 31st, exposed as above. Found twelve Puccinia graminis and five of Puccinia rubigo-vera.

It is evident, therefore that the red spores may be blown for great distances and that wind currents probably account for the wide general distribution of spores of rust, allowing a rust epidemic of one section of the country to furnish spores for other distant regions in which the crop is less mature.

Locally, windy weather at the time when the crop is most susceptible to rust is beneficial as it tends to keep the grain dried off, preventing the spores from lodging on the grain.

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* Conducted by Mr. F. J. Pritchard of this Department. It is to be noted that not all the spores caught were recorded, only those found in 6 cover-glass mounts for the microscope.

Cut 20. A view in the botanical garden showing the glass cages in which wheat was grown to maturity without rust, while the wheat from the same seed on the exterior became badly rusted. See page 644.

Dry, clear, windy weather following the milk stage will tend to hasten maturity and harden the straws. Such weather thus lessens the possibility of great rust development on the inside of the straws. Any feature of soil or climate which gives the crop rapid maturing conditions tends to save it from rust destruction. If, however, hot, drying winds follow a heavy actual outbreak of rust pustules on the crop, then the greatest possible crop destruction must folow.

Rain and Dew: In an irrigation district where the water is judiciously applied, in the absence of dew or rain to wet the foliage and straws, cereals are not attacked by the rusts because though the spores fall upon the plants, no germination takes place, hence there seems to be slight or no infection.[*] Rain has a direct and indirect influence. Excess of moisture causes rank, weak, succulent growths of straw easily attacked and destroyed by the rusts, and is apt to be followed by heavy dews which keep the plants damp so that a heavy infection can take place. Heavy rains in the regions in which the rust spores are mature and ready to be distributed, washes them to the earth and tends to prevent general distribution of the spores. Heavy dashing showers often repeated, just at the infecting time may also keep the air freed from blowing spores and keep the spores washed off the plants.

Dew is the form of moisture which most favors rust infection. It comes at night and remains in the form of drops or films upon the grain plants long enough to catch, hold, and germinate the rust spores and keep the delicate rust filaments alive until they have gained an entrance to the interior.

Drainage: Proper drainage will not materially affect the rainfall of any region, but it is always a great reducer of fogs and dews, which as explained in the last paragraph are the greatest causes of rust infection. In case of proper drainage, heavy rains and summer showers only tend to clarify the atmosphere and to cleanse the surfaces of the standing grain. On the contrary, large areas of shallow pools and swampy lands become heated during the hot summer days and furnish quantities of steaming moisture to befog the atmosphere and bedew the grain. The writer believes from extensive observations that for the five years following 1900 the average annual crop loss from rust alone in the Red River valley has exceeded one third the normal crop of that region; and that the befogged atmosphere arising from that poorly drained area distinctly outlines the neighboring areas of destructive rust influence in the states of North Dakota and Minnesota.

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[*] d This observation alone, if true in fact, seems almost sufficient to disprove the theory that rust infection can arise from internal infection of the seed.

The people of North Dakota and Minnesota should make every possible effort to have the drainage of this extensive fertile tract reclaimed to normal crop culture by a proper system of general drainage. It cannot be hoped that the drainage of a few local areas can give proper results. It is only the drainage of entire districts which can influence the atmospheric humidity and consequent dew formation, which is a matter of such great importance to this state. Besides, a proper lowering of the water table in this intensely fertile soil will remove the weakening influence of a sour water supply, so that there can be produced a sturdier harder strawed growth of grain more resistant to the destructive powers of all sorts of fungus parasites, rust included.

Local Condition Favoring Rust Infections, Development and Damage: Aside from the three general points just mentioned many local conditions influence the vigor of rust attack. These cannot be stated so definitely. They vary with the influnce of the greater factors. The most important of these local features are soil fertility, soil texture, mechanical condition of the soil, and soil drainage. Generally speaking any condition of the soil whether of mechanical, physical or chemical nature, which weakens the straw or retards its natural development just following heading time will be found to increase rust infection and the consequent destruction of the yield and the grade. I have observed the following features under which rust first becomes actively destructive: (1) Rust strikes early and excessively upon

Cut 21. Planting individual seeds from selected plants, showing the machine which allows one to plant every seed at exactly the same depth. This method of planting gives every plant an equal chance; the best plants for rust resistance are selected and saved. See pages 636, 670.

Cut 22. Threshing selected grain by hand so as to be sure that the different samples of grain do no get intermingled.

highly manured spots; on barnyard manures and animal droppings in excess on any land throughout the state. (2) In poorly drained spots of heavy, clayey lands of the valley. (3) On gumbo and alkaline spots not sufficiently loosened or pulverized, found in many of the lighter land areas of North Dakota outside the valley. (4) On light sandy, lands, which are too deficient in fertility to complete the maturing of a heavy crop of straw and heads developed in early season. Many people are trying to raise wheat upon a soil which is too light to complete the development of the spring growth. When rust comes on, this crop is sure to be destroyed. The soil is unable to push it to maturity against the rust attack. (5) On good loamy soils in various parts of the state, in which too much stubble, weeds and rubbish have been turned under. This unrotted stuff breaks the continuity of the soil, cutting off the regular supply of moisture from the furrow slice. (6) On fields of very good texture and fine fertility which have been overworked, either as a cultivated crop, or too thoroughly summer fallowed, thus putting the soluble plant foods in too available condition, giving an excess similar to that furnished by too heavy manuring with barnyard manures. For example, an excess of nitrogen makes soft, weak, succulent straw, and retards the power of maturing seed, but furthers the growth of rust. (7) On any type of soil if not properly compacted, that is, where left exposed to atmosphere, there being no proper soil continuity from below upward, etc.

Rust Resistant Varieties: During the seasons of 1894 and 1895 observations were taken upon the comparative rustiness of the various varieties of oats growing upon the Station farm and the results were summarized as shown in the following table:

No. and Kinds of Oats		Comparative Percentage of Rust in 1894	Comparative Percentage of Rust in 1896	Variation
1	Giant Side Oats..........	0	10	10
2	Archangel................	50	70	20
3	Prize Chester............	60	50	10
4	Early Everett............	45	30	15
5	Egyptian.................	30	70	40
6	White Schoenen (C. F.)....	55	50	5
7	White Wonder............	55	80	25
8	Wide Awake..............	20	40	20
9	American Banner..........	40	40	0
10	Progress	55	50	5
11	Badger Queen............	60	95	35
12	Race Horse..............	0	15	15
13	Salzer's Improved.........	55	40	15
14	White Russian............	55	40	15
15	Salzer's Welcome..........	40	85	45
16	Giant Yellow (Salzer's)....	65	100	35
17	White Schoenen (Salzer's)	50	50	0
18	Black Prolific	100*	100*	0
19	American Beauty..........	50	60	10
20	American White..........	85	75	10
21	Black Beauty............	55	90	45
22	Golden Giant Side........	5	15	10
23	Archangel (N. B. & G. Co.)	50	50	0
24	Dogheda..................	40	50	10
25	Great Northern............	45	100	55
26	White Bonanza............	45	90	45
27	Tartarian	0	1	1
28	White Swede..............	75	50	25
29	Black Champion..........	75	75	0
30	Giant Yellow (Angel)........	3	15	12
31	Black Russian............	50	100	50
32	Badger Queen............	65	100	35
33	American Beauty..........	50	60	10
34	Oats from N. Y. (unknown)	70	10	60
35	Fenton's Rust Proof.......	5	0	5

Cut 23. A bed of non-resistant rusted wheat, not much chance for selection.

36 American White Banner ..	60	70	10
37 Early Gotham............	75	75	0
38 Great Northern............	5	1	4
39 North Star...............	85	100	15
40 Early White Russian......	0	1	1
41 Lincoln	5	50	45

From these notes it is easily seen that for those years there were marked differences in the varieties in relation to the amount of rust attack. These observations have been continued in other years and it is found that the comparative resistance remains about the same, year after year, if the varieties are all seeded upon the same date. It is evident therefore that under equal conditions some varieties of oats are more resistant to rust than others. This assertion can only be made, however, for those which have essentially the same growth periods, that is, flower and ripen at approximately the same time. It has also been found that this sort of comparison can only be made to apply to one type of soil and climatic conditions. Varieties quite resistant in one locality may be quite non-resistant when placed under widely different climatic and soil environments.

These features have also been observed to apply to wheats and to other grains and grasses. We have lately made arrangements with Prof. Farrer of New South Wales, Australia, procuring many of the wheats which he has been breeding for rust resistance. Some of the numbers which were considered as having fine resisting powers for South Australia, when tried here in Fargo have been found to be quite non-resistant, indeed "Rerraf", the most noted of South Australian rust resisters, though ripening at the usual time for fife and blue stem, rusts so thoroughly here that it can scarcely produce seed.

Of this wheat in its native home, Mr. D. McAlpine says: "Trials of this wheat (Rerraf) show it to be a remarkably fine one, with clean straw, practically free from rust, only

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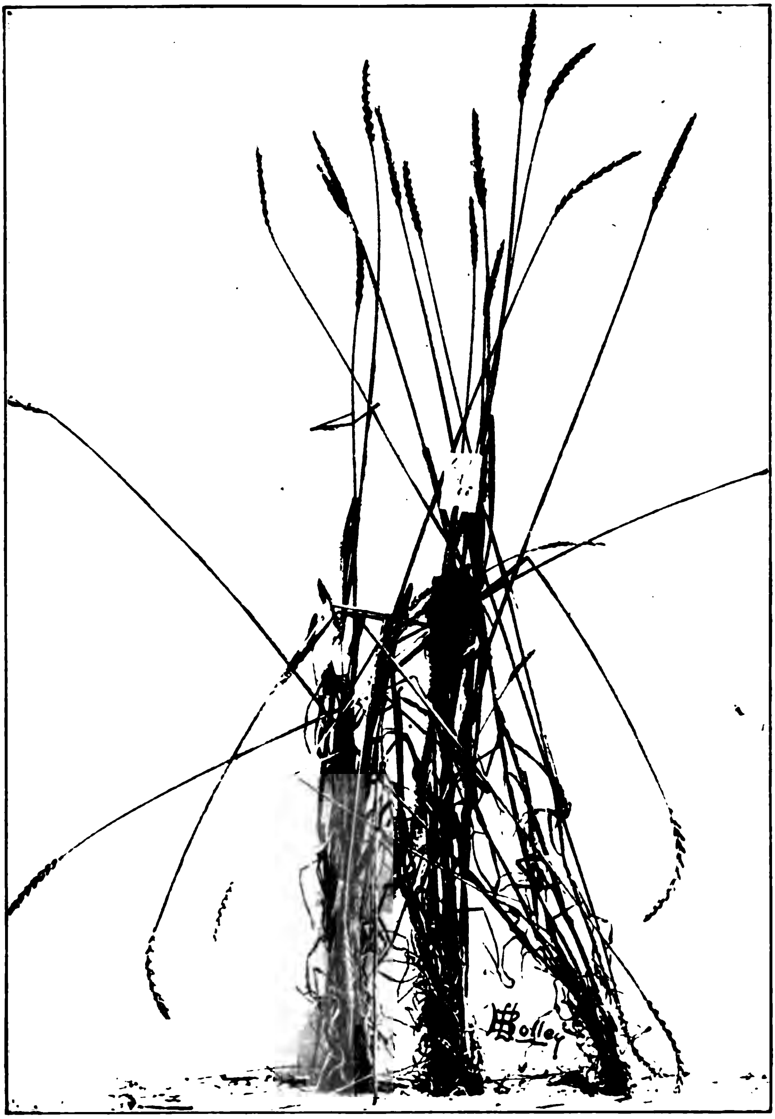
*When the crop was as rusty over the entire surface as seemed well possible, the rusting was rated at 100 per cent.

about two per cent. of the harmless spring rust (Puccinia rubigo-vera, occurring on the flag."

This then teaches that when considering selection of rust resistant varieties one must not expect them to show this quality with certainty if removed from the region in which the quality was gained. Observation has also taught the writer that one may sometimes mistake the simple escape of a variety from damage as representing rust resistant qualities. This may be due to some accident such as a variation in the date of planting. Experiments conducted in 1895 and since upon the effect of different dates of planting upon the occurrence of rust upon varieties of oats and wheat, show that the stage of development must be right for each variety before the general infection of rust usually takes place in the field. This accounts for the fact that a variety may escape rust one year and perhaps fail because of it another on the same farm. Some varieties, however, such as the Early White Russian oat, have been found to show strong resistance no matter at what date planted. Some early varieties of oats, such as six weeks have been successful in ripening before the rust reaches this region in destructive form. This variety of oat seems in reality to possess no resisting power. This feature of earliness may at times be of value, but cannot be relied upon. During 1905 numerous tests of wheat varieties were made involving this feature. It was observed that the rust reached maturity first on the earliest varieties and only a few of the very earliest got through without shriveled grain; and it is not certain that these may not have had some special powers of resistance.

It is safe to affirm that certain varieties of each cereal may be found which are particularly resistant to rust, if planted under the conditions by which the resistant qualities were first developed.

In selecting varieties, therefore, farmers should consider whether the soil and climatic features of their particular region tend to similate the native home of the variety. Thus, various varieties of durum wheats show marked powers of resistance upon rather light, drouthy soils, but are easily destroyed by rust in the damp, fertile soils of the Red River



Cut 24. Three stools of wheat from a bed which did not resist rust. The seed for this bed came originally from the same parent strain as that for the stools shown in Cut 25. See page 666,

valley. It may be well to note here that there are many varieties of durum wheats and not all of them show the powers of rust resistance usually ascribed to such wheats. It will be wise, therefore to keep each variety as pure as possible. Some come from regions liable to develop rust resistant features, others have never had much chance to gain these qualities, and are therefore quite sure to fail when exposed to rust conditions.

The Survival of the Fittest and its Relation to the Processes of Breeding and Selection to Escape Rust: Darwin put forth the idea that plants and animals vary in nature, that no individual is ever quite like its parent, and that it may have characters wholly different from either of its parents, that is, new characters. He founded his great idea of the origin of species upon these propositions, explaining that those plants and animals are on the earth to-day which happen to possess qualities of body and habits of life which fit them to resist the harsh conditions of nature with which they come in contact. This is the doctrine of the survival of the fittest. It has been found to be active in proper grain breeding operations.

Experiments at this station prove that the survival principle works well in breeding farm crops, and show that it will be easy for our farmers to help the process along in growing wheat and other crops. We have found that it has special bearing upon the methods which should be pursued to escape the action of diseases which attack farm crops. It is found that one can breed plants which take disease easily and types which resist disease. Indeed that it is quite possible to select and breed plants which are markedly resistant to such diseases, as wilt in flax and rust or smut in wheat.

It is possible that we may never secure crops of wheat wholly immune to rust action, but, that it will be possible to develop types of such rust resisting powers that rust will be able to do but slight damage, seems certain, and the principles are so simple that any farmer may engage in the work.

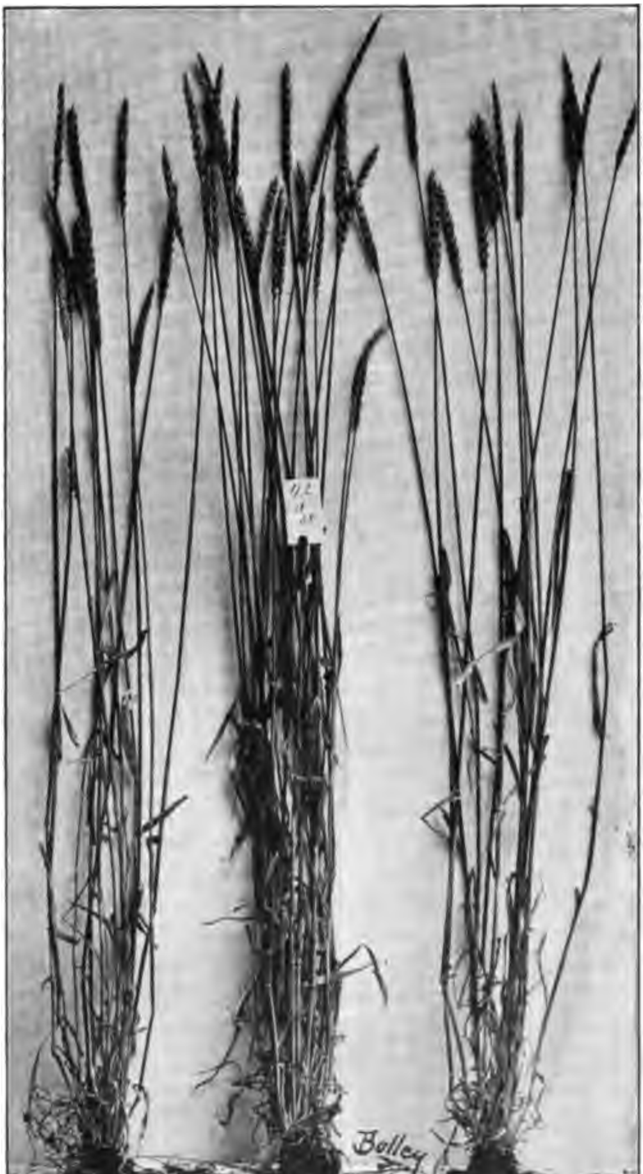
Principles Governing Selection to Procure Resistance to Rust: Experiments looking toward securing immune or resistant wheats and other cereal grains have not been of long standing, but those which we have been conducting at this Station allow us to note many characteristics which will help govern future efforts at breeding and selecting rust resisting grains.

All our tests and features show that the farmer may hope to procure very noticeable results by simply following the well known principle of selection by grading to form and weight quality in the seed. Rust shrivels the seeds of those mother plants which cannot resist it. Mother plants which are able to produce plump, well formed, heavy seeds during one rusty season have been found able to transmit this quality to the following crop, provided the crop is grown under similar conditions of soil and climate.

It is evident that these statements are but points emphasizing the feature commonly designated as heredity. One can expect his wheat crop, which is made up collectively of individual plants, to show only so much resistance to rust as the average of the individual plants have inherited. Thus, by grading out all those grains which do not reach the normal standard in rust years there is a certain way of eliminating the stock of poor heredity. It is also evident that farmers should gladly embrace the opportunity to do this, taking advantage of the fact that the shriveled grains point out the ones which come from non-resisting parent plants.

The principle of grading seed grain is not new, but many farmers do not believe in it, or, if they do, do not practice it. Our experiments, too extended to quote in full here,, show that an increase in yield and quality is always certain to follow such work, and further that the work tends to procure pure varieties and disease resistant crops.

Seed Exchange and Cereal Rusts: Considered from the above standpoint it is evident that the common practice of "seed exchange," simply for exchange sake, is one which proves a detriment to the hope of gaining rust resistant farm crops. Farmers must stick to the standard varieties and to the ones bred year after year upon their own or neigh-



Cut 25. Three stools of rust enduring wheat. Compare with Cut 24.

bor's farms, grading out all the types which cannot stand the particular conditions of that locality, soil and atmosphere.

The method followed by the writer in testing the resistance of wheat to rusts and smuts will serve to illustrate the points just emphasized. We place the plants or variety of plants to be tested under all of the disease producing conditions of soil, air and water that we can help nature produce. We plant the wheat year after year on the same soil. We coat the seed grains before planting with viable smut spores. We spray the growing wheat with a misty spray at the times when it is most liable to rust infection and dust over the crop an abundance of viable rust spores. Then, we save the seed from the best plants which survive and repeat the process year after year. The results have been most remarkable as evidenced after several years trial with the smut. The results of the work with the rust, though of but few years standing, is most remarkable.

Using the methods described above we have proved that many varieties of wheat, oats and flax cannot as crops resist rust, smut and wilt, but that there are almost always a great variation as to powers of resistance exhibited among the individual plants. There are always some individuals which show marked powers of resistance, even apparent immunity, and these plants seem able to transmit these qualities.

Whether such resistant individuals have gained that quality through gradual evolutionary change or whether it has come to them suddenly, is a matter for experiment and speculation .

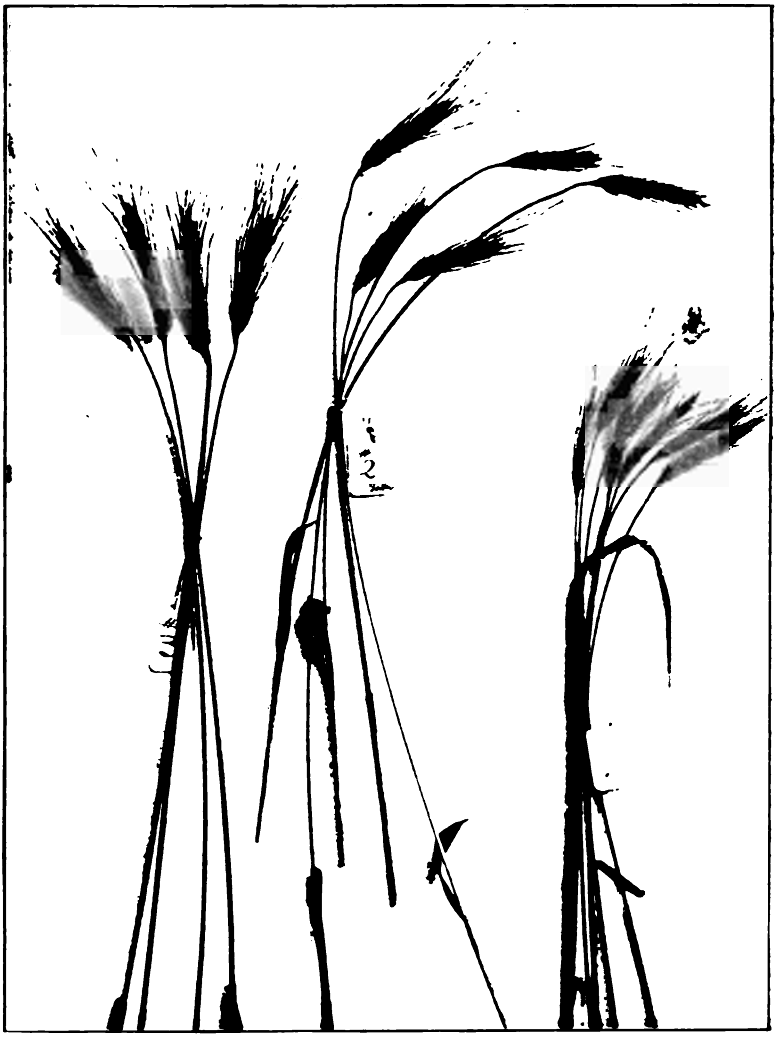
Whether resistant strains gained in this manner will prove to be permanent, remains for time to prove; but the work certainly establishes the fact that the "survival of the fittest" principle may be placed into active operation on the farm, and that the ordinary work of seed grading persisted in has a real basis in life principle.

It should be understood that the author does not advocate continuous cropping; but is only attempting to show that the principle of the survival of the fittest is always active even in cropping, provided the farmer does not through ignorance or perverseness fail to avail himself of its aid.

Even though such resistance may not be continuously transmissable generation after generation without lapsing, it is self evident that proper grading each year will keep the crop up to any standard of resistance which is once attained; for our work shows that the resistance certainly lasts through the next crop season. To accumulate this quality in the crops one must hang on to the type or pedigree.

The Use of Grain from a Rusted Crop for Seed: All experiments tend to show that under rust conditions of atmosphere, rust epidemics will come regardless of the source of the seed. As yet, no one has been able to prove the source of infection to be in the seed. (See page 645.) It is evident, if one is breeding wheat for quality, that he cannot afford to discard his seed every time of a rust epidemic. Our tests all prove that seed from a rusted crop no matter how much shriveled, if not otherwise injured, germinates freely under good soil conditions; and, if the average weight of the grains of a sample are above one-half the normal weight of sound wheat, will probably produce a stand when the usual amount of seed is used per acre. Such seeds produce thin stalked narrow leaved plants with weak vitality and slight powers of stooling. The large number of grains per bushel in part make up for the loss in living and stooling powers. Plants from light weight grains are always liable to die if the soil happens to be either poorly drained, heavy and cold, or very droughty just following the germination date. If light weight rusted wheat has been subjected to much wet, has been heated or weathered, it ought not to be used for seed. Shriveled rusted wheat never properly matures. It easily becomes soft and, in the presence of moisture, loses its growth, power much sooner than plump, hard wheat.

Even in most destructive rust seasons, there are few farmers who fail to raise enough heavy wheat for seed purposes. If there are no full weight grains in the crop, I can hardly recommend its general use for seed, because it shows that there was no rust resistant wheat in that field and because it will be hard to screen out enough heavy grains to insure a stand of strong plants. If, however, the grain is of a worthy variety, enough of the plump grain should be saved to improve the stock in this matter of rust resistance.



Cut 26. Three types of Durum wheat. Nos, 1 and 3 are great rusters and produced shriveled seed. No, 2 in a selected strain, selected for rust resistance in Russia in the summer of 1903. The straw of this grain has remained practically free from rust during the two seasons of 1904 and 1905, though surrounded on all sides by very rusty grain.

TABLE SHOWING RESULTS OF COMPARATIVE CROP GROWTH FROM SHRIVELLED AND PLUMP WHEAT FROM RUSTED CROPS. (*)

lot umber.	Origin of the Sample.	Weight of 100 Shrivelled Grains.	Weight of 100 Heavy-weight Grains.	Weight Straw and Grain Harvested.	
		(a) Grains	(b) Grains	(a) From Shrivelled Seed Grains	(b) From Plump Seed (Grains)
	(Book 5 Germination Record)				
31	(202) E. E. Dodd, Hope	1.01	1.991	443	454
32	(248) Chas. Scoville, Forman	1.168	2.216	286	428
33	(238) H. Hendrickson, Valley City	1.033	2.704	265	600
34	(232) Larsen & Lund, Kindred	1.156	2.843	296	578
35	(250) Isaac Malmen, Mayville,	1.357	2.839	277	527
36	(204) J. W. Smith, Fargo	1.315	2.518	310	430
37	(235) Thos. Rustad, Wahpeton	1.047	2.137	237	496
38	(UNKNOWN.)	1.306	2.618	537	588
39	"	1.291	2.476	503	530
40	(265) "	1.705	2.466	560	745
41**	(245) K. O. Skijostad, Pleasant Lake	1.765	2.32	520**	485**
42	(237) J. A. Power, Power	1.576	2.714	453	560
43	(UNKNOWN.)	0.855	2.29	375	800
44	(215) M. B. Olsen, Dwight	1.237	2.181	510	635
	Totals	17.812	34.315	5572	7848
	Averages	1.272	2.451	394	560

(*) The samples of seed used were from badly rusted crops of fife or blue stem wheat grown by different farmers of the state in 1904.

The seeds were planted in a ecrtgener machine so that each seed was

I can give no fixed rule as to weight, but recommend that grains which are to be used for seed purposes should at least be of three-fourths the normal size and weight.

Our experiments and observations during the seasons of 1904 and 1905 teach plainly that no matter what the variety of wheat, or what the sample, it does not pay to plant the light weight seeds found in a sample from a rusty crop. They should be graded out. The heavy weight seeds of the same sample always excelled the light weight seeds in growth from start to finish and excel in yield and quality production. The test also showed clearly that heavy weight seed graded from a rusted crop excelled in yield heavy weight wheat of same variety which had not been subjected to rust attack the previous season. Heavy weight wheat graded from a badly rusted crop shows markedly greater resistance to rust than either the wheat from rust shriveled seed or that which grew from plump seed of the same variety imported from a non-rust region. Many farmers of the state observed this feature in the crop of 1905. I quote from a letter from Hon. N. G. Larimore.

Larimore, N. D. July 1 1905.

Prof. H. L. Bolley, Fargo, N. D:

Dear Sir:—I wish to thank you for the advice you gave the country last winter and to the people for accepting and acting on it, in the matter of using home grown seed wheat in preference to seed that had not passed through the scourge. We had sold ours but on your advice bought it back, graded it and used it for seed. We believe that wheat

---

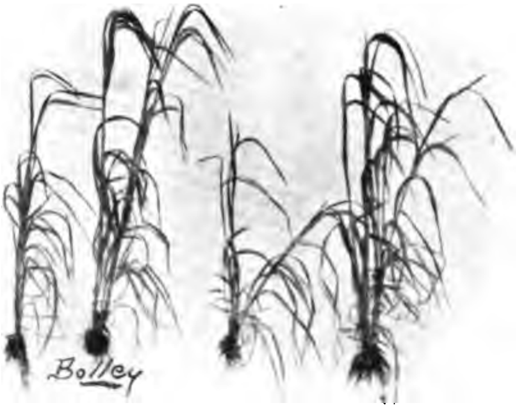
given exactly the same depth, and was placed exactly the same distance from each other. The ground had been cropped either to wheat or flax continuously for a number of seasons. No manure has been applied for a period of ten years.

The soil was of very even drainage and quality and all of the beds were planted on the same day. They matured evenly and were harvested on the same date.

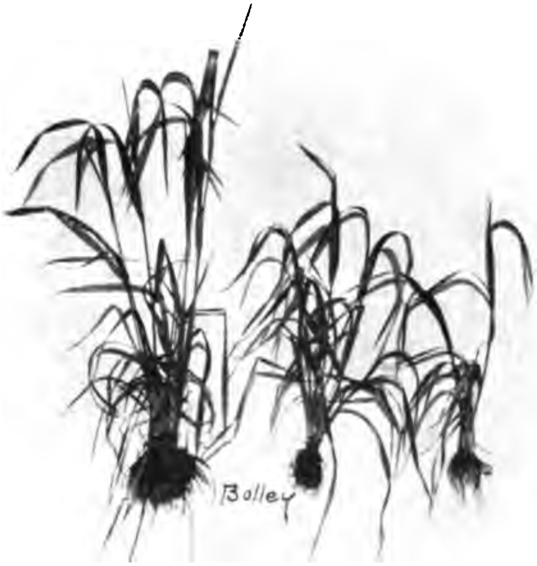
From the column of averages it will be seen that the "hundreds" of shriveled seeds weighed approximately one half that of the hundreds of heavy weight grains.

The yield of straw and grain from the plots was in favor of the heavy weight seeds in approximately the ratio of 5 to 3

(**) The only plot of heavy weight seed which failed to outyield its corresponding plot was No. 41, by the side of which was planted a small barberry bush. The infection of rust from this bush was so heavy that the straw of 41 was materially blighted, many plants breaking over before fully mature.



Cut 27. Stools of wheat from seed of the rusted crop of 1904 contrasting the growth from heavy-weight seed and light-weight seed of the same sample. See page 667. The seeds were planted at the same depth and on the same day.



Cut 28. Stools of wheat showing the effect of deep planting of light-weight wheat. The wheat weighed about 40 pounds per bushel. The grains selected were of the same weight but shriveled. The grains were planted on the same day, in the same bed but at different depths. The big plant No. 1, represents the growth when planted at inch depth. No, 2 is the average growth when planted at two inches of actual depth. No. 3 represents the average growth when planted at three inches depth. No plants came through the ground where the seeds were actually placed four inches.

had the smallpox last year. This year it has only the varioloid, and next year will be practically immune. One of our neighbors shipped in seed from a section free from rust last year. This crop from that seed is as badly rusted as ours was in 1904.

Truly yours,

N. G. LARIMORE.

It is possible that Mr. Larimore is slightly over sanguine in the premises, but he is not the only one who made similar observations during 1905.

It must be emphatically understood that rust does not seem to confer immunity upon the progeny by its attacks upon the parent plant, but if one grades out the shriveled grains after a rust attack he has left good seed, which came from the most resistant plants.

The way to procure the best possible seed wheat is to select a strain of a standard variety such as Blue stem or Scotch Fife which has been grown in the locality in which it is expected to use it, and each year that rust or other trouble comes improve it by grading out all of the shriveled kernels.

Rusted Straw as Cattle Feed: It is commonly asserted that rusted straw "is poisonous" and not suitable feed for stock. There seems to be slight foundation for this belief and much evidence to show the untruth of the same. Cattle, generally seem to eat such rusted straw with great relish when it is properly cured, and never seem to be injured thereby. It is probable that all cases of poisoning could, on investigation, be traced to some such matter as dried water-hemlock or other poison weed. The water-hemlock is often abundant in poorly drained wheat fields. Chemical analysis has shown that straw from a rusted crop contains more proteids, fats and other product of forage value than does straw from a properly mature non-rusted crop. The Central Experiment Station of Ottawa, Canada, has found that rusted straw may run as high as 7.64 per cent. of proteid as against 2.44 per cent. in ordinary straw. This is but natural as the general rust attack comes at a time when practically all of the nourishment and manufactured products are in the leaves and straws and thus prevents the transportation of a large per cent. of these to the heads and grains. Thus such elements must remain in the straw.

Summary of What to Do: (1) Drain your fields so that all surplus water will quickly run into main ditches. Get together with your neighbors and open all main ditches which are now blocked, and open more new ones if necessary to insure the general drainage of entire districts. Co-operative efforts to attain proper general drainage of all cereal producing areas of the United States will greatly lesson the liability of rust epidemics. My observations teach that rust is seldom able to bring about great crop destruction in large districts of proper soil texture and drainage. It is, however, a matter of common observation that a slight fermentation of the soil water, due to stagnant surface water has ruined many a fine crop upon very fertile soil and that rust under such conditions always becomes very destructive.

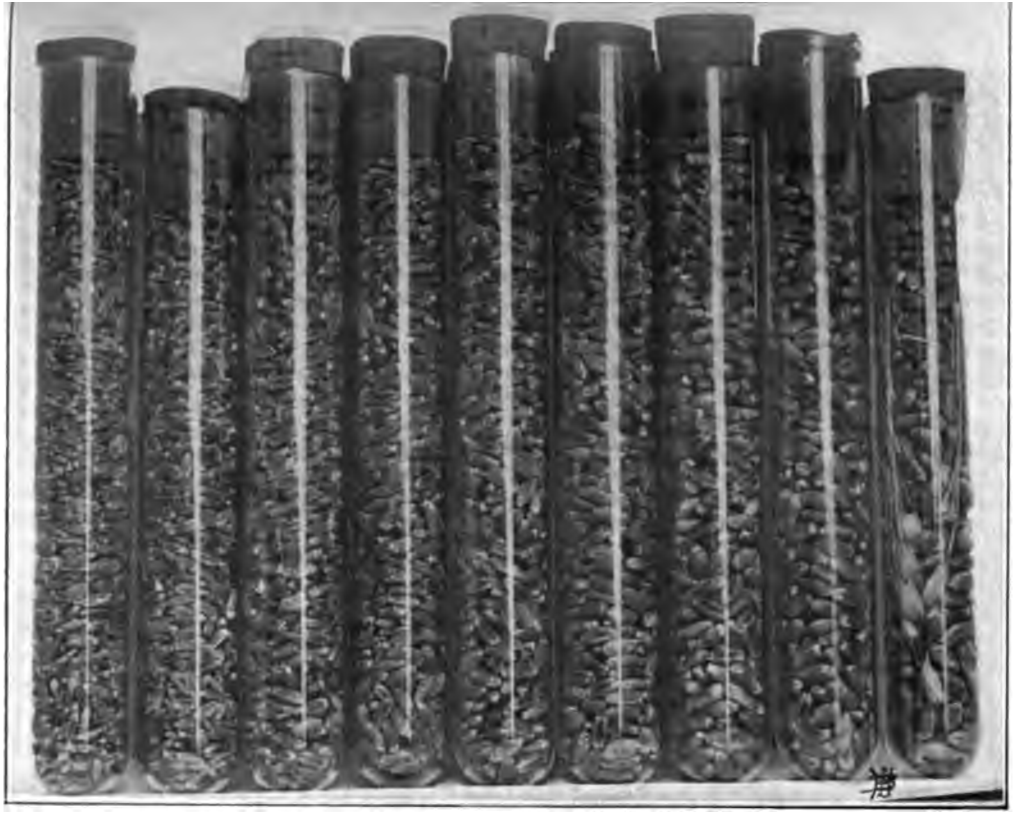
(2) Make every effort to have the crop mature at as early a date as possible, that is, shorten the vegetation period as much as possible. The first wheat seeded in the spring gives the best yield and best grade, and usually is out of the way of the attack of rust. It would be best for all concerned, if it were possible for the people of one community to sow all of their wheat within the space of a week or ten days. The late fields are always liable to rust destruction because of the first slight infection spreading from the early fields.

(3) Make a good even seed bed with good soil continuity from below upwards, and bury the seed at an even or regular depth so as to insure even development of the crop.

(4) Sow clean seed of the best germinating strength possible. Such seed tends to advance the crop rapidly, hastening the date of the harvest, ripening it to such strength that the rust cannot reduce it.

(5) Sow only seed of a pure variety as Blue Stem, Scotch Fife, or a pure variety of Durum. A pure variety ripens evenly and gives an even grade. The soft bearded varieties of wheat scattered in a crop rust early and produce great quantities of spores to infect the surrounding wheat. These scattering plants of soft wheat always furnish grain which will reduce the grade of crop.

(6) Treat all seed for the prevention of smut. Smut weakens the growth of the entire crop and retards the devel-



Cut 29. This photograph shows the importance of grading seed wheat before planting. The seed in these tubes were all graded from one sample of the rusted crop of 1904. We recommend sowing only such seed as is shown in the last four tubes. See page 666.

opment of the straw. On a smutty crop the rust action is always intense, insuring its destruction.

(7) Keep the crop as free of weeds as possible. Weeds weaken the straw, retard maturity, and tend to keep the leaves and straw of the grain fogged with moisture, especially during the cool, dewy nights. Weeds also prevent the grain from drying off after the slight warm showers which are the most effective in causing rust infection. When the grain needs the moisture to push it to maturity, the weeds rob the soil of that which is needed to fill the grain. Such wilting grain is sure to suffer greatly from rust infection.

(8) In winter wheat regions it will be found of advantage to destroy all early volunteer growths of wheat. They perpetuate the rust by means of the red or summer spores.

(9) To save the spring wheat crop from the rust scourge it will be necessary to keep the winter crop confined to its own area southward. Avoid planting small trial patches of winter wheat in the spring wheat belt.

(10) Keep the wild grasses and weeds of the roadsides mown. They serve to transmit the rust from field to field by producing an early crop of summer spores. Especially keep down the wild barley and the native wheat grasses, quack grass, etc.

(11) Kill all barberry shrubs. This should be brought about by Legislative Enactment, if it cannot be otherwise.

(12) Cease the useless process of "seed exchange." Exchange or buy new seed only when a grain of known pedigree can be obtained, one which is proved to be a better yielder and to be more disease resistant than that of your own breeding.

(13) Grade all seed grain to seeds of perfect form and normal weight.

(14) Rotate the crops so as to give each cereal crop the sturdiest possible growth.

(15) Proper seed selection and care of the same and proper soil cultivation and drainage of the same, will, I believe, eventually overcome these rust diseases, the most destructive of all farm troubles.

HENRY L. BOLLEY.

Agricultural College, N. Dak., Jan. 1906.

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Cut 30. Heavy-weight seed vs. light-weight seed. Two stools representing the average growth and merits of each type of seed. See pages 667, 670.